

CHAPTER 1

INTRODUCTION

Motivation, Objective and Scope

1.1 Motivation

Combustion of fossil fuels in power stations inevitably generates sulfur dioxide (SO_2) which is a highly significant pollutant in the atmosphere. Acid rain is the subject of the considerable concern throughout the world. It is now regarded as fact that pollutants play a major part in the current damage to lakes and forests. With the burden on the environment, industrialised countries are reducing emission of sulfur dioxide. The most common technology for sulfur dioxide control is "Flue-gas desulfurization (FGD)".

Flue-gas gypsum (FG) is one of calcium sulfate compounds that obtained from the desulfurization of combustion gases from power plants. FG is moist, fine powder and contains only minor quantities of impurities. So, the FG is purer and more consistent surpassing the quality and performance of natural gypsum (NG). Therefore, under a proper quality control this gypsum can be used by the gypsum and cement industries without purification.

For the manufacture of gypsum building plasters and multiphase plaster (MP), the FG must be treated before calcination to get rid of the free water. In case of MP, it is also necessary to modify the particle structure by means of agglomeration. Because of both fineness and crystal structure of FG are important factors that determine its rheological properties. So, in those days these properties made the use of flue-gas gypsum less attractive when compared with NG.

In Thailand, FG is a waste from desulfurization process and at present

a useless material but countries (e.g., Germany, Japan and Canada) lacking of NG resources and having more stringent environmental protection are increasingly using this gypsum as raw material for gypsum industries which has led to the progress of gypsum technology. The large quantities of FG available in the future will put a strong impact on the recycling of FG elsewhere and hence the cost of processing FG and that of disposal by dumping are becoming more competitive.

1.2 Objective

Since gypsum industries are the potential consumers of FG, the objective of this research is to convert FG to β -hemihydrate (β -HH) and multiphase plaster (MP). β -HH plaster is intended for gypsum building components (e.g., plaster board) and MP for both building components and plastering.

1.3 Scope

The scope of this work covers the study of FG from Mae-Moh Power Plant on its chemical and physical properties relevant to the process of gypsum plaster. Conversions of FG to β -HH and MP are done by calcining in air in electric furnace on a laboratory scale. The calcined products are characterized and shaped into specimens for mechanical testing. The finishing performance of MP projection plaster is also carried through.

1.4 Literature survey

Gypsum has been recognized as a valuable building material for several thousand years. The Greeks and the Egyptians both used it to advantage in structures which still stand.

As an interior finish, gypsum plaster is durable and versatile. Over

the past thirty years, considerable progress had been made in the Federal Republic of Germany towards development of a factory made machine-applied gypsum plaster. Since 1965 machine-applied plaster has been produced in a large quantity. It is used to finish interior walls and ceilings. Ordinary MP was used as the starting material for multiphase plaster and by incorporating with chemical additives, it was processed into a material that could be used for continuous machine that operated inside the building, supplied with plaster directly from bins or containers installed just outside the building by pneumatic conveyor pumps through flexible hoses (Fig. 1.1). Such a plastering machine could be operated by one person and the plaster can be applied in a single coat. The rates of setting and hardening process had been adjusted to suit the longer working cycle for material applied over a large surface area (Hamm et al., 1974).

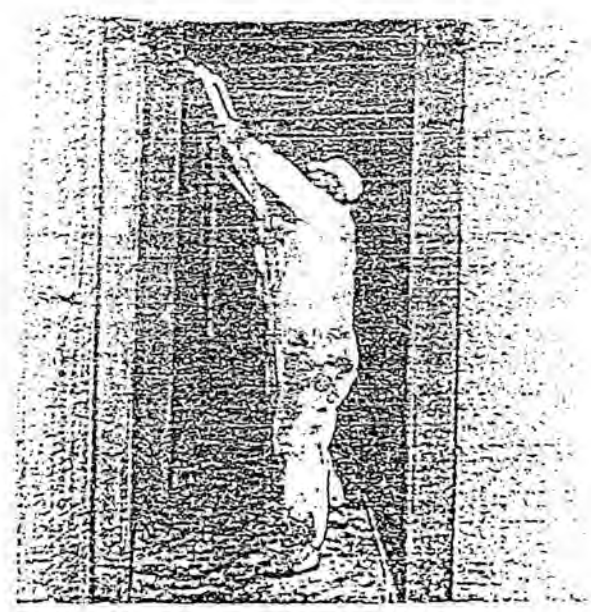


Fig. 1.1 Plaster applied over gypsum lath by machine (Hamm et al., 1974).

Knauf (1961) reported a method for the preparation of MP for producing construction plaster in a conveyor kiln (Fig. 1.2). Before being fed to the conveyor kiln, the gypsum rock was crushed and split into three or

four sieve fractions. The fractions were piled on the continuous conveyor grate, the smallest on the bottom. The grate, which moved continuously past through a calcining hood. The top layer could reach a temperature up to 700°C and the bottom layer up to 300°C . The gypsum was not mixed during calcination.

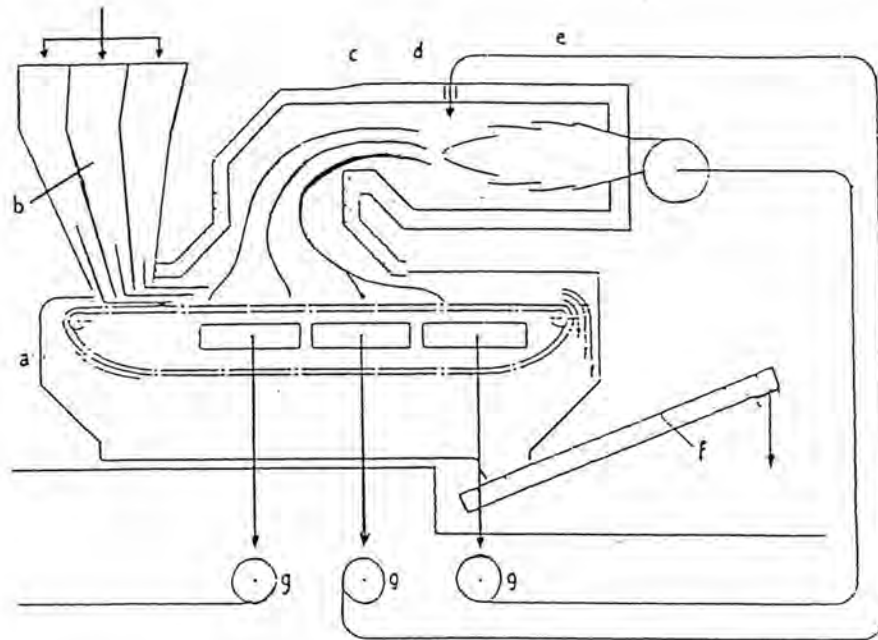


Fig. 1.2 Conveyor kiln for the production of MP a.) Conveyor grate, b.) Feed hoppers, c.) Calcining hood, d.) Layer of gypsum, e.) Combustion chamber, f.) Discharger, g.) Circulating and cooling air fans for exhaust gas (Wirsching, 1975).

In 1974, Landrieu, Gibarie and Collomb (1974) produced MP by mixing overburnt plaster that produced from conveyor kiln with β -HH which produced from rotary kiln, to produce projection plaster (Fig. 1.3).

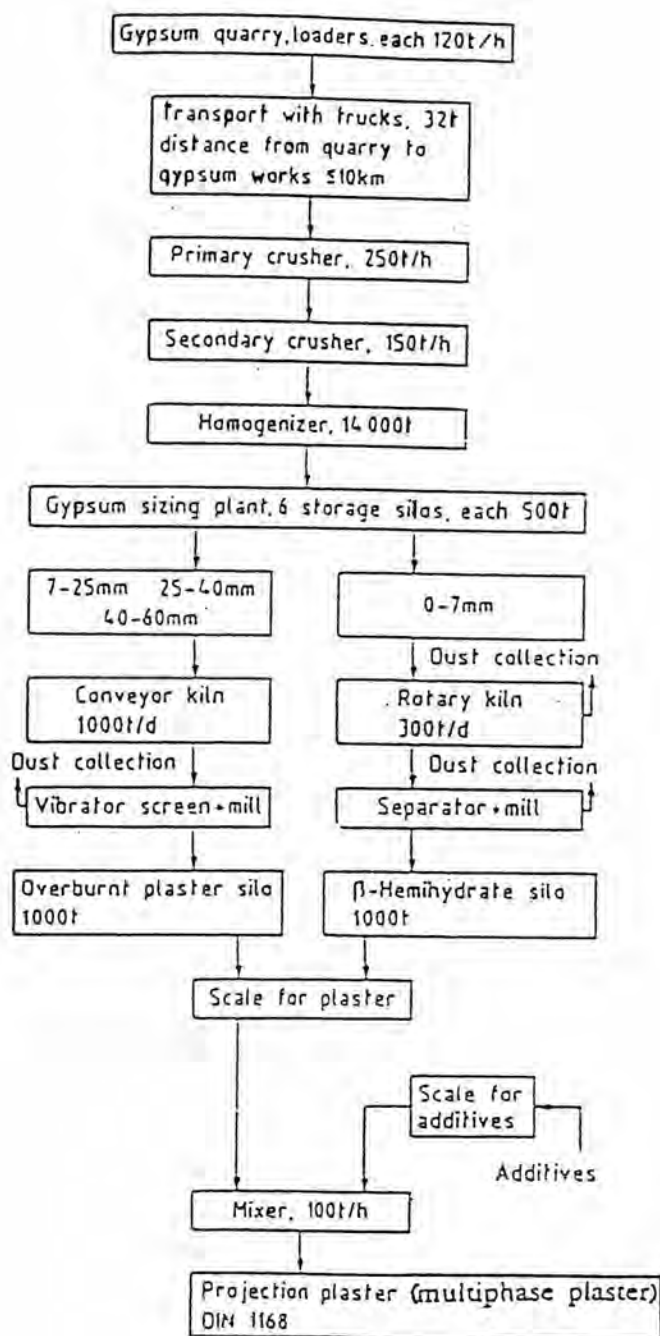


Fig. 1.3 Flow diagram for production of projection plaster (Wirsching, 1975).

Heian (1978) reported the use of by-product from desulfurization process as a raw material to produce MP by calcining the by-product at temperatures between 300–900°C in a rotary kiln (Fig. 1.4).

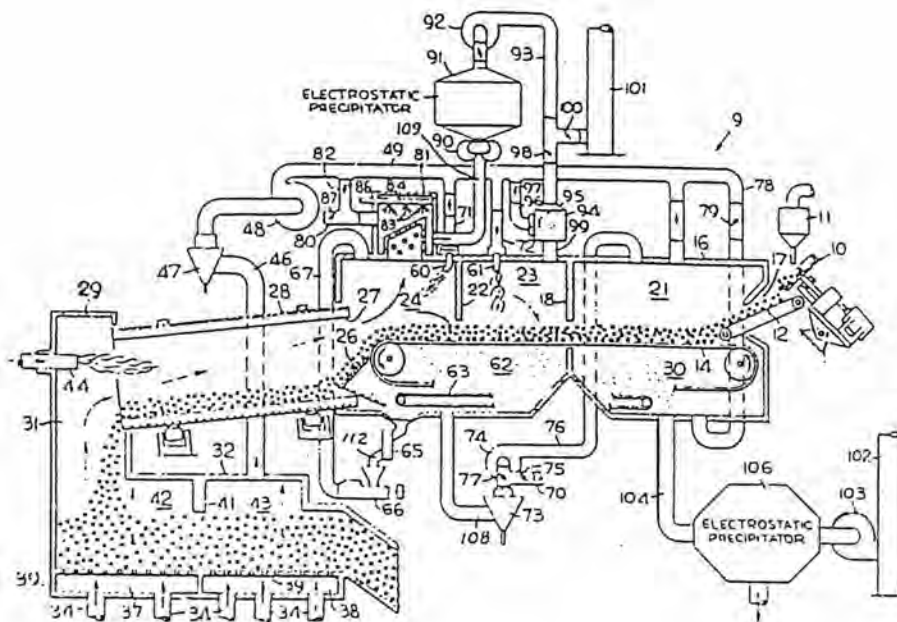


Fig. 1.4 Production of MP from by-product in a rotary kiln (Heian, 1978).

Cornetis and Janssen (1990) reported the process for preparing anhydrous plaster from FG. The process was conducted by recrystallization the DH at moderate temperatures $400\text{--}900^{\circ}\text{C}$ in the presence of sulfuric acid having a concentration of 40–65 wt%. The particle size of the final product was controlled by varying the temperature and residence time of the recrystallization mixture in recrystallization zone.

Boos and Wirsching (1991) proposed the process for producing MP by heating a flowable powder of FG moistened with less than 20% by weight (preferably from 7 to 17% by weight) of diluted sulfuric acid. The total mixture was direct fired or rapidly heated with indirect heat exchangers having relatively high temperature whereby it was heated at temperatures between $200\text{--}600^{\circ}\text{C}$ and then the virtually MP product was annealed at temperatures between $200\text{--}600^{\circ}\text{C}$ for 0.3 to 24 hours.

Gypsum plaster board, the modern version of plaster interior finishing, provides a smooth, durable surface with a minimum amount of effort and expense. It is simple to install, light, porous, dry, nonbrittle products

possessing excellent workability and can be painted, stippled or papered. β -HH is the starting material for this because it sets quickly and easily meets the building industry demand for certain properties of the finished product.

Brittain and Elliott (1923) prepared β -HH by atmospheric dehydration of ground gypsum in a kettle kiln at a temperature of 130°C . Guha and Sen (1959) reported a method for preparation of β -HH in shaft or rotary kilns (Fig. 1.5) at a relatively higher temperature where besides the main formation of the β -HH, some anhydrite might form.

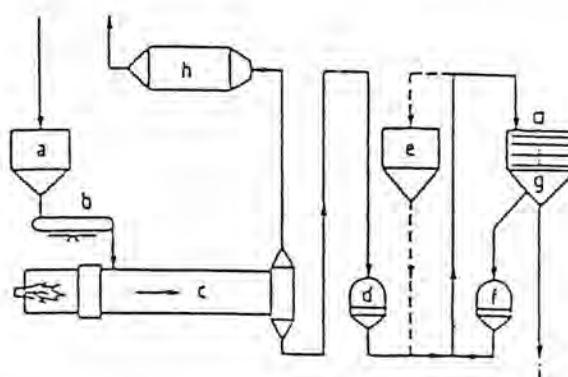


Fig. 1.5 Production of β -HH plaster by the rotary kiln process. a.) Silo for gypsum rock, b.) Weigh-belt feeder, c.) Rotary kiln with combustion chamber, d.) Primary mill, e.) Start-up and shut-down bin, f.) Fine mill, g.) Air classifier, h.) Electrostatic precipitator, i.) β -HH plaster (Wirsching, 1975).

Blair (1962) and Ward (1980) improved the kettle process and made continuous. Predried and finely ground gypsum was fed continuously from above. The calcined gypsum settled at the bottom of the kettle where it was continuously discharged through a pipe connected to the side of the kettle (Fig. 1.6).

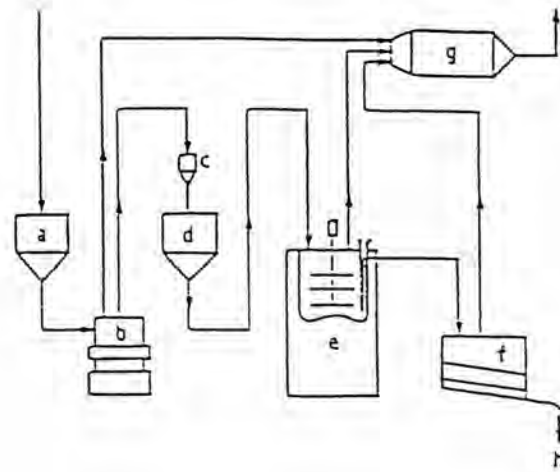


Fig. 1.6 Production of β -HH by the continuous kettle process with combined drying and grinding. a.) Silo for gypsum rock, b.) Drying and grinding unit, c.) Cyclone, d.) Kettle feed bin, e.) Continuous kettle, f.) Cooling bin (hot pit), g.) Electrostatic precipitator, h.) β -HH plaster (Wirsching, 1975).

Klein and Ruffer (1993) reported a method by which β -HH was produced using an indirectly heated calcining process to avoid possible impurities caused by the fuel preference. Kettle kilns with continuous operation and methods of heat recovery were preferred to produce β -HH at temperature about 150°C .

Francis (1994) investigated temperature range to produce β -HH by means of calcining gypsum in kettle kiln. In his report, 1.5 molecules of the chemically combined water were driven off, leaving a half molecule of water remaining while calcined in air at atmospheric pressure within temperature range 120 – 170°C .