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# AN IMPROVED MECHANISED PAN SYSTEM FOR CALCINING GYPSUM

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**Gypsum continues to be one of the important materials for building and ceramic industry. Since it finds applications usually in the form of plaster of Paris, the calcination of gypsum becomes a significant operation in the production of plaster for market use. An improved mechanised pan calcination system for gypsum has been developed at the Central Building Research Institute (CBRI) which brings about considerable saving in fuel and is more efficient than the traditional open pan calcination method. The gypsum samples calcined in the prototype set-up comply well with chemical and physical requirements of relevant Indian Standards. The paper describes salient features of the improved mechanised pan system and recommends it for use in building, pottery and surgical grade plasters on commercial scale.**

## INTRODUCTION

Gypsum is one of the important non-metallic minerals applicable in the manufacture of cement, fertilizers and plaster of Paris, specially as raw material for cement and sulphuric acid[1], as a filler in the paint, rubber or paper industry and for the reclamation of soils for agriculture use. India is rich in deposits of natural gypsum, with total reserves estimated to exceed 1205 million tonnes[2]. Gypsum mines are mainly situated in the states of Rajasthan, Tamilnadu, Gujarat, Jammu and Kashmir, Andhra Pradesh, Uttar Pradesh and Maharashtra. Out of the total reserves of gypsum, 1100 million tonnes are obtained from Rajasthan. Besides natural gypsum, about 2.1 million tonnes of by-product phospho gypsum is also available annually from the fertilizer plants[3]. It contains phosphates, fluorides and small quantity of organic matter as impurities. These impurities adversely affect the setting properties and strength development of plaster. However, processed phospho gypsum can be used for the production of different types of building materials[4]. Industrial importance of gypsum is attributed to its dehydrating ability on heating. Manufacture of gypsum plaster of different grades like surgical and building requires the mineral to be calcined to hemihydrate or plaster of Paris. Gypsum as such has no binding properties. On heating at 120-180°C, gypsum loses one and a half molecule of water of crystallisation forming hemihydrate or plaster of Paris which dissolves upon addition of water. The saturated solution precipitates needle shaped crystals which later set into a hard and strong mass. This property of gypsum is utilised in the production of pottery, terracotta and many other ceramic products. Since hemihydrate gypsum constitutes the market form of available gypsum, calcination of gypsum to hemihydrate state becomes a significant operation.

## 2.0 DIFFERENT METHODS OF CALCINATION

Different methods of calcination of gypsum include: kiln process, open pan process, continuous rotary kiln process and kettle process. These are briefly described below.

### 2.1 Kiln Process

This is the most primitive method in which the calcination of gypsum is accomplished in any form of kiln or oven often constructed on the lines of backer's oven. The gypsum is agitated by long pokers. A typical kiln used in West Germany[5] comprised of a long room 2 meters in height built with brick walls above a furnace. Cars loaded with gypsum (6 mm size) were allowed to enter the room (oven) on regular car tracks. The kiln could be fired with oil, coal or wood. The direct contact of flue gases with gypsum loaded in the car was prohibited. The temperature inside the room was maintained at about 140°C for 30 to 36 hours. The oven could be emptied three times a week yielding 8 to 9 tonnes of calcined gypsum per charge. This method is specially applicable in preparing calcined gypsum for porcelain trade.

### 2.2 Open Pan Process

This is the simplest process of calcination prevailant in many countries. In India, this process is most widely used for the production of gypsum plaster for building purposes. Gypsum ground to about 60 mesh is placed in open metallic pans, heated from below by burning fire wood or coal. Burning of the charge, is avoided by manual agitation with the help of pokers. Initially, gypsum loses sufficient amount of water in the form of steam. The material settles when calcination is complete and emerging of steam stops. At this stage, heating is discontinued and the hot calcined gypsum is taken out from the pan with the help of spades.

### 2.3 Rotary Kiln Process

Small rotary kilns similar to the ones used for cement

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manufacture are employed for calcination of gypsum. The kiln is fed with lumps of gypsum of size not greater than 30mm. In view of lower temperatures required for calcination of gypsum and also to avoid contamination of the charge with unburnt fuel and ash, a special combustion chamber outside the kiln is employed separately instead of direct firing of fuel in the kiln. Complete combustion of fuel occurs in the chamber and only the hot gases are allowed to come in direct contact with the gypsum. The calcined gypsum from the kiln is sent to the grinding mills. The plaster produced in the rotary kiln process is most adaptable for use in wall plasters and boards[6]. However, this quality of plaster is considered inferior to those produced by the kettle process.

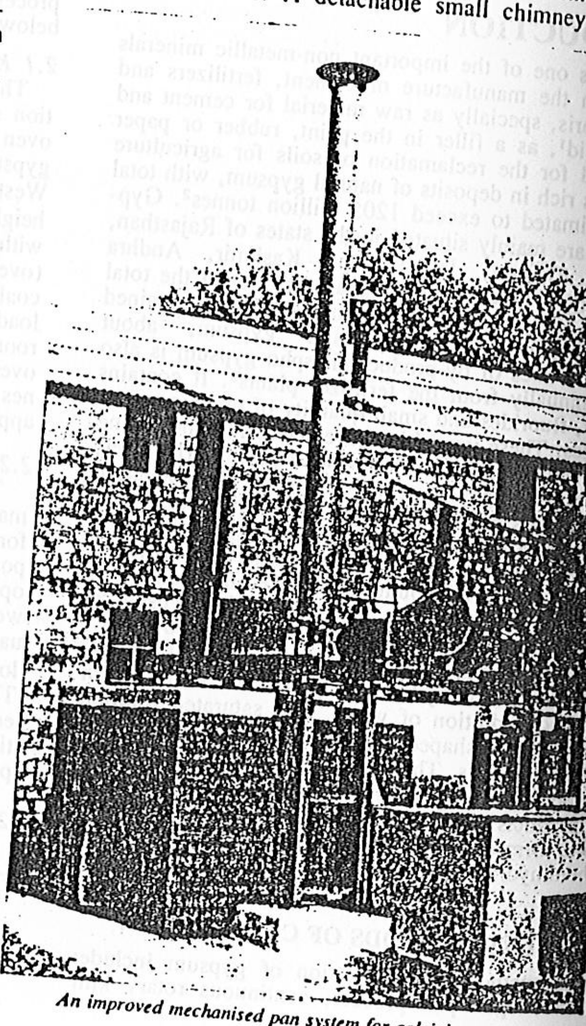
*2.4 Kettle Process*

Kettles of different designs and sizes varying from 10 to 30 tonnes are used. Basically a kettle consists of a cylindrical metallic vessel heated externally from its bottom side and fitted with various controls. Technical data like fuel consumption, power requirements, thermal efficiency, capacity and maintenance cost for calcination of gypsum in kettles have been summerised by Riddell[7] on the basis of operating experience. These vary with the nature of gypsum used and its fineness after grinding and method of operation. Kettles are mostly of batch operation type but the continuous operation type kettle with submerged burners have also been reported by Ward[8]. The advantage of submerged combustion technique is that the extra heat can be added directly to the charge without increasing the temperature at the bottom of the kettle. It also raises the fuel efficiency of the system upto 83 per cent. These kettles are of fairly large size and are of highly sophisticated design. CBRI[9]-designed kettle is a vessel of one tonne capacity. The kettle comprises a metallic shell heated from its bottom side. A motorised revolving vertical shaft with blades placed inside the kettle helps in churning of the charge[10].

Amongst the above four methods, open pan system is mostly used in India for reasons of simplicity in design, operation and low initial cost of installation. However this system has several drawbacks: heat is wasted, dust loss is high — upto 20% and the plaster produced is not of uniform quality being sometimes under burnt or over burnt in different portions of the charge. Further, open pan system cannot be used for calcination under controlled temperature, a feature which is most important in the calcination of gypsum as the properties of gypsum plaster are influenced not only by the quality of gypsum used but also by the control over the calcination temperature, extent and method of churning the charge and the duration of calcination. As a result of growing awareness towards energy conservation in production units, a mechanised kettle was developed by CBRI[9] for improving the calcination of gypsum. The kettle has been used for commercial production but is considered as too sophisticated and costly for the production of plaster of Paris particularly for building use. Another factor that adversely affects the use of kettle is its design which is totally different and much deviated from the popular design of open pan system. A survey of gypsum industries reveals that the manufacturers are interested in simpler yet efficient systems possessing all the advantages of the kettle byt economic and easily adaptable on the existing open pan set-ups. Accordingly a new system named as 'Improved mechanised pan calcination system' has been developed at CBRI and the prototype has been successfully tried for its performance.

## 3.0 IMPROVED MECHANISED PAN SYSTEM

The improved mechanised pan calcination system (Fig. 1) has two main sub-assemblies, pan assembly and furnace. The pan assembly comprises of two mild steel pans, each of 500 Kg capacity, a churning mechanism which has a power operated vertical shaft (one for each pan) carrying a number of churning blades and other power driving mechanisms. The churning mechanism is so designed that the charge in both the pans can be churned simultaneously or individually whenever required. A 5 HP motor runs the churning mechanism. Provision has been made for manual churning also but this should be used only in situations of electric power failure and protection of the charge under calcination against burning. The bottom of the pan is designed for having better heat transfer between the flue gases above the grate and the gypsum charge in the pan. The shape of the bottom helps in automatic discharge of the hot calcined gypsum into storage pits. Each pan is supplied with a lid to check dust losses. A detachable small chimney is pro-



*An improved mechanised pan system for calcining gypsum.*

vided on a hole made in the pan-lid for the escape of water vapours to atmosphere during calcination. This hole is also used for charging gypsum into the pan. A vertical cylindrical shaft furnace of low height is employed in which the main structure of the furnace is made of building bricks while the inner side is lined with fire bricks. The pan is placed directly on the top of the furnace and heated by flue gases generated in the furnace. A flue gas ring is provided in the brick work around the vertical sides of pan so that the flue gases emerging from the grate and passing through this ring may give up some of their heat to the gypsum charge inside the pan. Flue gases are finally liberated to the atmosphere through a chimney. The furnace is designed to be operated either on coal or fire wood. During operation, the furnace is lighted by placing wooden pieces and small amount of coal on the grate. Later more coal is added till the system gets heated for about half an hour. At this stage the ground gypsum is fed into the pans while the churning mechanism is already on. On further heating, gypsum boils giving out the water of crystallisation. Boiling is continued for about one hour at 130°C and during this period, the temperature remained constant at 130°C. As the temperature exceeds 130°C, steaming reduces considerably and is stopped at 170°C when the material is subdued. The calcination of gypsum is complete at this stage and the hot calcined gypsum is tapped out into the storage bin.

### 3.1 Fuel Efficiency

Data regarding coal consumption in open pan calcination system indicates that 150 to 200 Kg of coal is consumed for calcining one tonne of gypsum. The trials carried out on the CBRI Kettle[9] indicate that with all the advantages of mechanical stirring, elimination of dust losses, etc., the fuel consumption in the vessel cannot be lowered below 70 Kg of coal per tonne of gypsum. However, in case of improved mechanized pan system, it has been observed that with a theoretical heat required for 1 Kg of plaster of Paris as 162.55 K Cal[7] and calorific value of steam coal used as 5500 K Cal/Kg, the thermal efficiency of the system is about 55%. Since the coal consumed is 45 Kg per tonne of gypsum, it indicates that the system is far more efficient in fuel consumption compared with open pan and CBRI Kettle.

### 3.2 Salient Features

Salient features and advantages of the system are described below.

1. It's capacity is one tonne per charge.
2. The time taken by the first charge is about three hours while the subsequent charges are calcined within two and a half hours.
3. Coal consumption in the system is about 45 Kg per tonne of gypsum.
4. The pans are enclosed steel shells and hence the dust losses of gypsum are totally eliminated.
5. Uniform churning of the charge is ensured through continuous mechanical stirring.
6. Loading of gypsum in pan is done manually but discharging of hot calcined gypsum is done automatically. The hot gypsum is discharged directly into the storage pit under sealed cover that completely eliminates the dust problem.
7. The system can be operated on coal or fire wood.
8. The system is compact and easy to operate and maintain.
9. The system can be easily and advantageously adapted on the existing open pan system with minor changes.

### 3.3 Trials of Calcination

Calcination trials were carried out on the prototype using i) Rishikesh gypsum of 89.22 and 80.62% purities and ii) Rajasthan gypsum of 85.14% purity. The gypsum plasters produced were tested for chemical and physical properties as per relevant IS Standards. Results have been reported elsewhere[11]. The plaster samples conform to all the requirements laid down in the relevant Indian Standards.

### 3.4 Cost Economies

The cost of system has been estimated as Rs.35000.00. Presuming a total capital investment of Rs.3.77 lakhs for the production generating facility of 1512 tonnes of plaster per annum and assuming the selling price of plaster as Rs.450.00 per tonne, the return on the investment has been found to be about 50.74 per cent.

## 4.0 CONCLUSION

The improved mechanised pan calcination system developed at Central Building Research Institute has low initial investment enabling large savings in fuel cost. It is more efficient than the existing open pan system in several respects. The system is recommended for commercial production of gypsum plasters of building, pottery and other grades.

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