Reducing Water Demand

Bob Bruce, Charles Blow and Gary Murray, The NuGyp Corp., Canada, describe how the NuGyp LoCal™ process saves money and the environment.

Introduction

Gypsum, chemically known as CaSO4.2H2O, has been used as a building material for thousands of years. It is found worldwide in easily accessible mineral deposits and has become available more recently as a byproduct of various chemical processes, such as the scrubbing of sulfur dioxide from flue gases of coal burning power stations. Use of gypsum became widespread when it was discovered that it could be heated to produce the hemihydrate form (calcination) and then solidify once again (hydration) when the calcined powder was remixed with water (Figure 1). This formed the basic chemistry for a range of gypsum based plasters and precast products, such as wall plasters, gypsum blocks and plasterboard (gypsum board or drywall).

With usable gypsum being low cost, readily available and easily processed, the gypsum industry has continued to grow worldwide for many years. Plasterboard building systems are now used almost exclusively for interior walls and ceilings in North American, Western European and some Asian countries. Light weight plasterboard building systems are very cost effective in construction and offer excellent resistance to fire, sound, water, shear, impact, abuse, mould, vermin, etc. Plasterboard use will continue to grow for many years to come as it becomes more available in developing and emerging countries. The recent earthquake in Haiti is a good example of where plasterboard systems could have saved many lives if this had been the predominant building system for both residential and commercial structures.

Gypsum plasters can be manufactured by a range of processes, with the most common methods producing the "beta" hemihydrate, a fast setting product. The desired properties of this material are the result of the highly disordered and high-energy surface that results from these calcination processes. These unique surface properties are such that the freshly produced hemihydrate particles will typically need 80 ml of water to mix with 100 g of the plaster to give a plaster slurry that will pour, in spite of the fact that it only needs 18.7 ml of water to completely hydrate this 100 g of plaster. Figures 2a and 2b illustrate the same plaster with water mixed at ratios of 80/100 and 65/100.

During the manufacture of

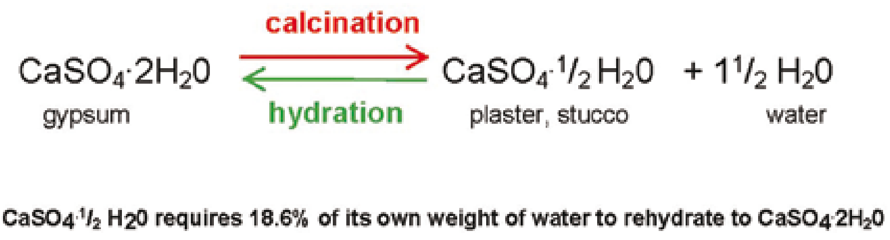

Figure 1. Pure $CaSO_4 \cdot ½\, H_2O$ requires 18.6% of its own weight of water to rehydrate to $CaSO_4 \cdot 2H_2O$.

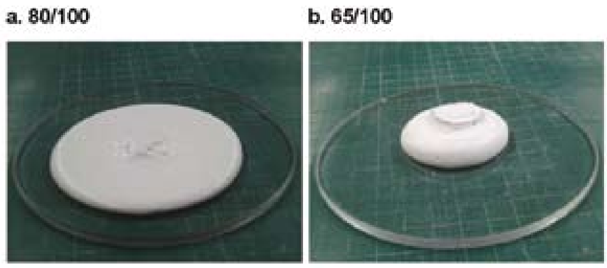

Figure 2a and b. Water to plaster ratio (W/P)

plasterboard, the slurry is poured on the 1.2 m wide cardboard liner and must quickly flow to the edges in time for the back liner to be applied. Sufficient water must be added to the mix to allow the slurry to flow quickly, this amount of water being called the water demand of the plaster.

A problem of energy

For plasterboard, energy is needed to dry the original gypsum, calcine the gypsum to plaster and then dry off the excess process water over and above what is needed for hydration. A modern high-speed board plant running at 500 ft./min (160 m/min) evaporates over 1500 lb of this excess process water (700 kg) per minute from the board produced. The USA Energy Information Administration reports that the natural gas deliveries in the United States in 2008 were 21.3 million $ft.^3$. Their records show that roughly one third of this was used for home heating, one third was used for power generation and the remaining one third (7 trillion $ft.^3$) was used to fuel industrial processes. During a typical year in North America, the gypsum industry will produce about 35 billion $ft.^2$ of gypsum board. Taking into account the energy required to dry the gypsum, calcine it to plaster, and then dry it for sale takes roughly 2 MCF per thousand square feet or about 70 million MCF. This means that the gypsum industry is consuming about 1% of the natural gas used by industry in the United States with a total cost of over US$500 million at a delivered price of US$7 per MCF. Given the recent concern regarding climate change, it is incumbent upon the gypsum industry to do whatever is possible to reduce this energy consumption, especially if the water/natural gas is not actually required for the manufacturing process itself. In some regions of the world where water is in short supply, it would be beneficial to use less water in the process in order to conserve both water and energy.

Much work has been done over the years by the industry to address this problem but an ideal solution has been elusive. It is possible to make a lower water demand plaster by calcining in an autoclave to make the "alpha" hemihydrate, but the capital and operating costs are prohibitive. Dispersing agents are used but can be expensive and are limited in effectiveness. "Aridization", natural "aging", "deadburning", fine grinding and water sprays have all been used, but result in varying degrees of added cost, reduced strength or other process problems.

The solution

In 2005 two companies joined forces to address this problem, Innogyps Inc. in Canada and CasoFour Ltd in the UK. After trying several options, it was discovered that if freshly calcined beta plaster was exposed for a short time to steam at modest pressures above atmospheric then the water demand of the plaster could be reduced substantially, up to 40%. Figure 3 gives an illustration of the process. This plaster treatment process has been demonstrated to be very simple to perform and allow the water demand to be reduced as required to a predicted level by increasing the exposure time and/or pressure of the steam to the dry powder. Contrary to previous plaster treatment processes, the quality of the stucco is maintained with no harmful effects on either strength or setting properties.

After performing hundreds of laboratory tests at Innogyps, a larger pilot scale apparatus was built that was suitable for shipping to plasterboard plants around North America. To date three versions of the pilot apparatus have been used at four locations using three different types of calcining equipment and four different kinds of gypsum. Previous laboratory results were confirmed by these pilot test results in the plant setting using fresh plaster from the actual calcination process used in making the plasterboard.

The results of the laboratory and pilot tests are shown in Figure 4 below. The chart on the left shows the water demand reduction typically achieved at various temperatures and steam pressures. The chart on the right shows the % reduction in drying energy that should be achieved at these same pressure / time settings. As experience grows it is expected that the plasterboard plants will learn to add more air to the slurry to displace even more water resulting in reduced energy or dispersant costs. Work is ongoing to help plasterboard manufacturers make full use of this technology by producing board at ever lower water to plaster ratios.

With the success of the laboratory and pilot trials, patent applications were made and are pending in 71 countries around the world. A new company was formed, The NuGyp Corp., to facilitate commercialisation of this technology. Since the product of this process has water demand more like alpha-hemihydrate but setting and strength properties more like beta-hemihydrate, it was given a new Greek letter designation nu-hemihydrate, after the Greek letter "v". As discussions were held with various companies in 2008 to move the process to full-scale production, Gypsum Technologies Inc. purchased a minority equity stake in the company with the goal to supply the necessary production equipment to use this process in gypsum plants around the world. Gypsum Technologies, more commonly known as Gyptech, is one of the leading suppliers of gypsum board plants for the gypsum industry. The three shareholder-directors of The NuGyp Corp. have over 90 years combined experience in gypsum technology, engineering, operations and market development.

Case study

After viewing laboratory demonstrations at Innogyps Inc. and pilot scale trials, Panel Rey S.A. installed full scale equipment to treat the continuous kettle stucco from the mill in the Monterrey, Mexico board plant. The production scale equipment from Gyptech was commissioned during November 2009 and as of 1 December 2009 has become standard practice within the plant. This project "Estuco Ecologico" is part of Panel Rey's ongoing commitment to improving the environmental impact of the Monterrey plant for climate change and global warming.

At the time of installation there were two significant risks:

- Can the NuGyp LoCal™ process be scaled up to operate at a rate sufficient to supply a modern board plant at full production?
- Will the stucco from the NuGyp LoCal™ process flow through the bins, elevators, and metering systems without giving any difficulty?

So far, the results show that the NuGyp LoCal™ process has:

- Not resulted in any deterioration in the quality of the board product produced in the plant.
- Proven a hand mix water demand reduction of 14% and 7-second blender mix water demand reduction of 18% under process conditions used thus far on the board plant; with opportunities yet to increase treatment times and pressures.
- Shown operating costs for the process are only a fraction of the cost saving achieved.
- Run under automatic control in concert with normal mill control.
- Had no negative impact on the downtime or availability of the mill or the board plant.
- Resulted in almost no change in board line operating conditions other than the water demand reduction described above. Stucco handling, storage and metering remain unchanged. There was a small increase in accelerator but within the normal range of usage. The full range of product types and thicknesses were manufactured without encountering any problems.

These results in the board plant could not have been accomplished without the support shown by Panel Rey President Nicolas Alverde and Plant Manager Marco Patino; as well as the diligent and outstanding efforts by the plant operating and engineering staff of the Monterrey plant. They should be commended for assisting in bringing this new energy saving process from pilot scale possibility to full scale reality.

The NuGyp LoCal™ process can also be used in applications beyond plasterboard production.

For special plaster production, the NuGyp LoCal™ process will:

- Allow production of a range of high value low water demand special plasters from any existing calcining mill.
- Reduce the manufacturing costs of low water demand high strength gypsum plasters.
- Reduce substantially the capital and maintenance costs of producing special plasters.
- Allow low water demand plasters to be made with a range of gypsum feedstocks.
- Allow production on demand of special plasters of hand mix water gauge of 55 to 80 ml/100 g from the same production facility.

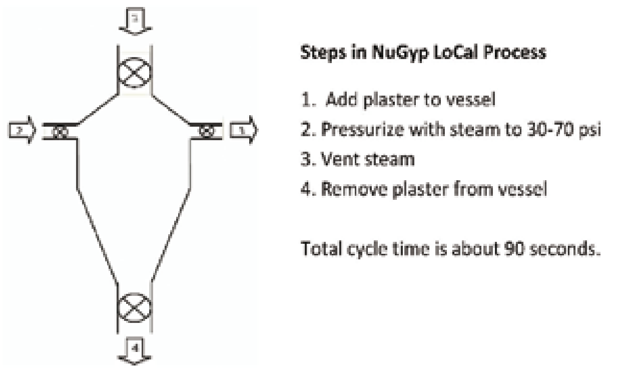

Figure 3. Schematic of NuGyp LoCal™ Process.

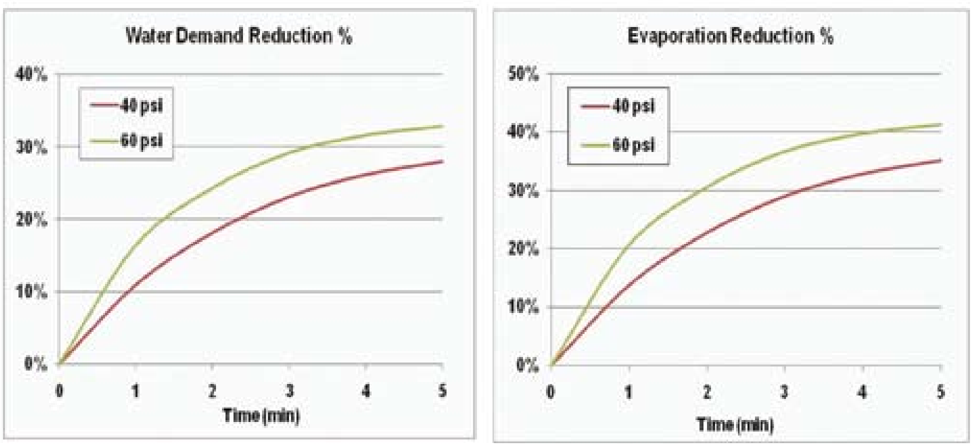

Figure 4. Water demand and evaporation reduction.