SIGNAL MOUNTAIN CEMENT – A SUCCESS STORY IN PROJECT EXECUTION AND TECHNOLOGICAL EFFICIENCY

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INTRODUCTION

Through the combination of the latest technology and intuitive project management skills, the Signal Mountain Plant expansion project proved to be a successful venture for all those involved. While the original plant consisted of wet process lines, the new line rated for 2200 MTPD would be a state of the art dry process line. Through the design of the equipment and coordination within the project management team, the plant was able to exceed their performance expectations.

Plant History

Signal Mountain Portland Cement Company was established in 1920.The original plant was built just five miles from downtown Chattanooga in an area known as Glendale on a site that was originally prepared by the Chattanooga Steel Company. The location was particularly advantageous for cement manufacturing. There existed over one mile of riverfront on the Tennessee River, limestone and clay needed for production were on site and coal existed nearby on Signal and Raccoon Mountains. The Chattanooga Traction Company's railroad ran through the property so the necessity of building company housing did not exist. On October 12, 1923 the first clinker was produced through the 3-11' x 175' kilns.

The plant was sold in 1947 to General Portland Cement Company. In the early 1950's the quarry became a problem so production was shifted to a leased quarry 25 miles from the plant. The plant went through several upgrades during the late 50's and early 60's with the installation of two 11'3" x 425' kilns and two 13' x 16' finish mills but remained "wet". In the fall of 1981 General Portland was purchased by LaFarge

and in 1982 LaFarge sold the plant to Italian and British investors. Currently the plant is owned by RC Cement Company, which is a wholly owned subsidiary of Buzzi Unicem S.p.A.

Project Planning and Execution

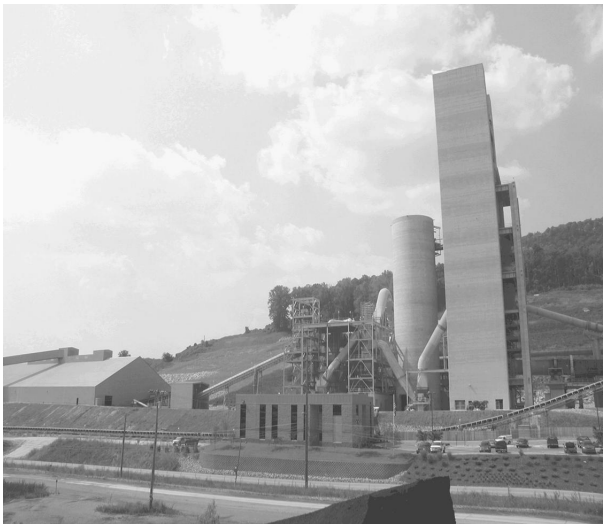
RC Cement and Unicem, RC's parent company at the time, decided in 1996 to increase the capacity and modernize their Signal Mountain plant. General plant design was completed on the original layout in 1997, however Buzzi Cement purchased Unicem in 1997. This change in ownership resulted in an improved plant design that incorporated the experience of the new owner.

The project was truly "owner directed" with personnel from RC, Signal and BuzziUnicem managing all of the aspects of the work. Contracts were awarded to several suppliers for major plant equipment, engineering, structural steel and all plant auxiliary equipment. In addition RC's personnel handled the design of the control system and coordinated all of the startup activities.

This particular way of managing a project created a great challenge to the people involved. The project management core group consisted of eight people who were a combination of RC and Signal employees assigned to areas of engineering and procurement, construction, purchasing and project accounting, electrical and automation. Additional external personnel were hired to aid in the various areas

In addition to managing the project the group needed to coordinate the training activities of the existing plant personnel. A plan was developed that utilized the local universities to establish programs for the future control room operators and maintenance technicians who have skills in both mechanical and electrical repair. Vendors provided additional equipment specific training on operation and repair.

Plant Technology and Performance



Construction of the plant began in October 1998. By April 2001, the plant was fully staffed with a multi-vender commissioning team for the start of the raw mill system. By July 2001, the pyroprocessing system had reached its rated capacity of 2200 mtpd.

New equipment for the plant spanned from the quarry to the finish mill. The following description highlights the latest technology installed at Signal Mountain.

- **Quarry Operations**

Primary Crusher:	Nordberg C 140B
Jaw Crusher:	250 Hp
Secondary Crusher:	5.5 Symons Cone
Cone Crusher	300 Hp

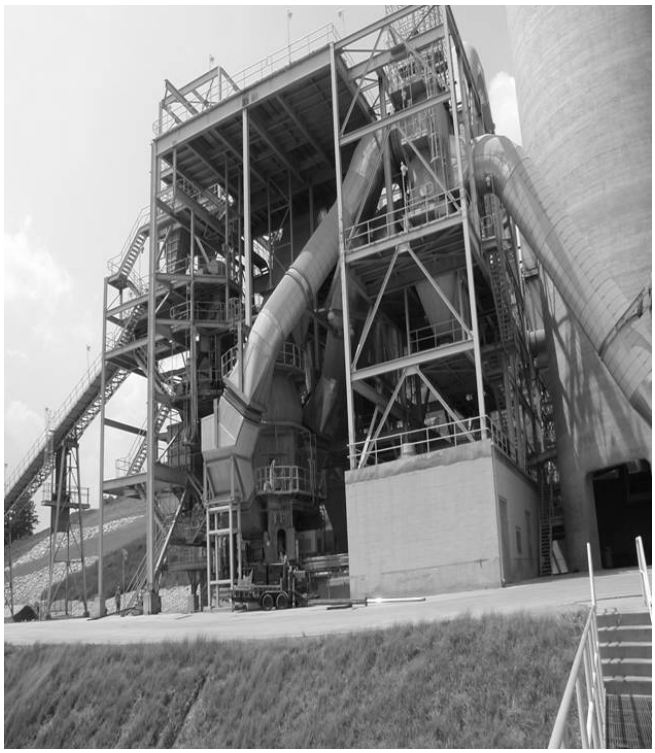
The quarry operations are located approximately 25 miles from the plant along the Tennessee River. Two types of limestone are mined from the quarry, a low magnesium limestone (2.5% MgO) and a high magnesium limestone (3.5%). Together, both types of limestone supply the main component for the raw material mix. The high MgO limestone accounts for approximately 25% of the mixture and the low MgO

limestone accounts for 59%. It is estimated that the existing quarry will provide the plant with 75 years of raw material reserve.

A jaw crusher is utilized as the primary crusher for the two grades of limestone in the quarry. Size reduction of the crusher feed is performed between two crusher jaws, one being stationary, and the other movable, each lined with ribbed liners. Material enters the crusher through the top cavity, offering top crushing performance, combining high reduction ratios and increased capacities with any feed material characteristics.

To further crush the limestone, a secondary cone crusher was installed. Together, the crushers produce a limestone with a fineness of 89% passing 4" and 13% passing 1".

Product from the quarry and 4 other components (Slate, Iron Ore, Sand, and Bauxite) are stored in a 30,000 mt longitudinal storage facility located at the plant site. The storage area is divided into sections, each having separate weighfeeders for each raw material in order to dose the individual component to the raw mill system.



- **Raw Grinding**

Make:	Loesche LM 38.4 LSKS 56 Classifier
Motor Size:	Mill – 2250 Hp
Capacity:	175 MTPH

Throughout the years, the vertical grinding mill has provided plants with excellent grinding efficiency, high production capability, and high drying capacity, making it the most common mill system for raw material grinding. The vertical raw mill utilizes both the horizontal grinding table and the large tapered rollers under hydropneumatic loading to achieve the required production rate while minimizing the wear.

The mill system at Signal Mountain is a three fan system that utilizes kiln exhaust gases to dry the raw material. The raw mix is received directly from the longitudinal storage hall, with no intermediate storage bins for surges. A triple gate feeding system allows the feed to enter the mill while providing an air lock to the mill. The raw mix quality is constantly analyzed through an on-line analyzer located on the feed belt. The high efficiency separator produces product with a product fineness of 12% retained on 90 microns. Product from the mill system is sent to the 4,000 mt blending silo.

A unique feature of the raw grinding system is the two cone valves installed to control the hot gases to the raw mill. These valves allow for regulation of the kiln gases and to maintain proper air volumes and temperatures within the mill. Through the innovative design of the cone valve and cooler vent system the plant was able to combine these two gas streams into one common baghouse thus eliminating the need for a separate cooler vent system which resulted in a savings of capital.

PERFORMANCE RESULTS

The commissioning of the raw mill was successful. A performance test was completed during the commissioning phase of the project. The achieved results can be seen in ***TABLE 1***:

CONDITION	GUARANTEED RESULT	ACHIEVED RESULT
Production (mtph)	175	>175
Fineness	<12% retained on 90µ <1% retained on 200µ	Guarantee achieved
Specific Power Consumption (kWh/mt)	7.5 (mill motor, classifier drive, auxiliaries, and triple gate feeder)	Guarantee achieved
Raw Material Moisture Content	4%	4%
Raw Meal Product Moisture Content	<0.5%	0.5%

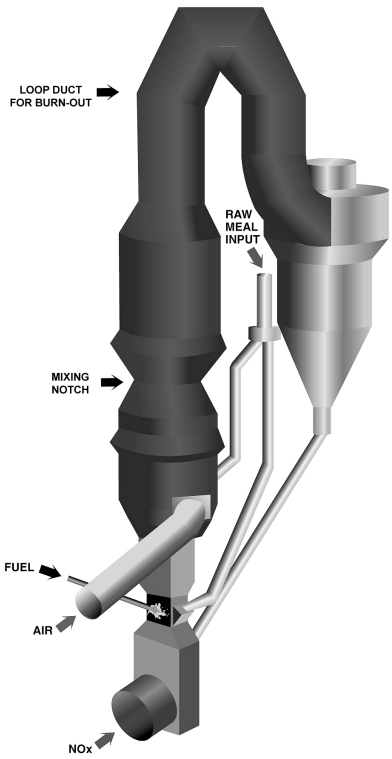
TABLE 1: Raw Mill Performance Results

- ***Pyroprocessing System***

  F.L.Smidth 5 Stage Preheater with Low- NO_x ILC

Cyclone sizes:	Stage 1: 5.4m Ø LP Cyclone Stage 2: 5.4m Ø LP Cyclone Stage 3: 5.4m Ø LP Cyclone Stage 4: 5.7m Ø LP Cyclone Stage 5: 5.7m Ø LP Cyclone
ILC low NO_x Calciner:	6.6m Ø x 20.0m Long ILC w/ extended mixing duct
Capacity:	2200 mtpd
Kiln:	F.L.Smidth 3.95m x 47m two support kiln
Cooler:	F.L.Smidth SF 2x4 Cross-Bar™ Cooler

The five (5) stage preheater tower at Signal Mountain was designed to be both architecturally pleasant and efficient. The tower is built with two sided columns, with both rectangular columns made of cast-in-place concrete. This design allows for the elevator, downcomer, kiln feed system, stack, and all other auxiliary equipment to be hidden from plain sight.



Signal Mountain incorporated two unique features in the Pyroprocessing system, the latest design for In Line Low NO_x Calciners and the SF Cross-Bar Cooler.

Feed from the blending system enters the five (5) stage preheater through the gas inlet duct of the Stage 1 cyclone. The material is preheated throughout the first four stages of the preheater before it is split to both the calciner and the reduction zone. Feed to the reduction zone controls the temperature of the gases and minimizes the potential for build up often common in this area.

The calciner is designed to burn 100% petroleum coke (petcoke) efficiently while minimizing both the NO_x and CO emission levels. The design of the calciner allows for 100% of the fuel to be

introduced in the kiln riser duct. From here, a combination of kiln gases and fuel enters the rectangular reduction zone where concentrations of O_2 are low and the gas temperature is high. These conditions provide for the strongest reduction in both *fuel* NO_x and *thermal* NO_x. Gases remain in the reduction zone for approximately 0.2 seconds prior to entering the In Line Calciner.

To facilitate the burning of 100% petcoke with minimal CO emissions, several unique design considerations for the calciner were included. These consist of the single entry for the tertiary air gases, the "notch" in the body of the calciner, and the loop exit gas duct. The tertiary air enters the calciner through a single entry at the base of the calciner. A high circulation of the kiln gases, unburned fuel, and oxygen rich tertiary air promotes a more complete combustion of the fuel. Additionally, mixing of the gases and fuel is further promoted while passing the "notch" in the cylindrical portion of the calciner and the extended exit gas loop duct. Gases entering the calciner incur a retention time of 7 seconds before they enter the Stage 5 cyclone. This allows for the complete combustion of the fuel, with minimal carbon carry on to the kiln and minimal CO emission rates. The calciner consistently produces high calcination rates, typically between 85% and 90%.

The second unique equipment installed in the Pyroprocessing system is the SF Cross-Bar cooler with a Hydraulic Roll Breaker. This cooler has a five (5) row cooler inlet, followed by eight (8) paired Cross-Bar modules. This cooler has no movable grate plates, no clinker fall-through, and no requirement for an undergrate clinker conveying system. The innovative Cross-Bars allow for the effective conveying, mixing, and shearing of clinker, while at the same time preparing the clinker for efficient exposure to the cooling air. Cooling air enters the cooler through the revolutionary mechanical flow regulators. These regulators maintain a constant air flow to each plate via a self-adjusting orifice. The regulator automatically compensates for variations in clinker bed height, particle size distribution, and temperature to maintain a constant air flow to each grate.

Signal Mountain's cooler was designed for a tertiary air take-off from the side of the cooler. During normal operation, tertiary air temperatures range from 875°C to 950°C, while secondary air temperatures range from 1050°C to 1200°C. These high temperatures result in a very fuel efficient kiln system and allow for quick ignition of the petcoke.

Cooler vent gases are vented to both the raw and fuel grinding system to provide heat for drying of the raw materials. By venting the cooler vent gases through the grinding system, an emission stack, and ultimately an emission point, is eliminated from the design.

PERFORMANCE RESULTS

The kiln system was successfully commissioned. ***TABLE 2*** shows the results during the performance test.

CONDITION	GUARANTEED RESULT	ACHIEVED RESULT
Production (mtpd)	2200	2300
Clinker Temperature	60ºC above ambient	69ºC above ambient
Fuel Consumption (kcal/kg clk)	710	700
Stage 5 degree of Calcination	>85%	>90%
%C in Stage 5 material	<0.25%	<0.06%

TABLE 2: Pyroprocessing System Performance Results

EMISSIONS

In today's market, maintaining the required emission levels is essential to the successful operation of the plant. The Pyroprocessing system was designed not only for efficiency, but to minimize such emissions as CO, NO_x, and SO_x.

Through Signal Mountain's selection of raw materials, CO and SO_x normally emitted from the top of the preheater tower are minimized. The design of the calciner allowed for the minimization of emissions resulting from the combustion process.

Through the optimization of fuel consumption, gas temperatures, and chemistry, ***TABLE 3*** shows the results Signal Mountain was able to achieve.

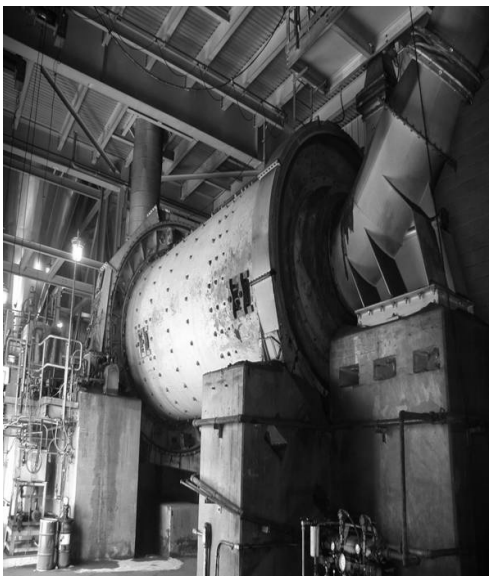
CONDITION	GUARANTEED RESULT	ACHIEVED RESULT
CO (lb/hr)	248	Achieved Guarantee
NO_x (lb/hr)	403	Achieved Guarantee
SOx (lb/hr)	89.5	Achieved Guarantee
ILC exit CO	<700 PPM	150 PPM

TABLE 3: Emissions Results

- ***Fuel Grinding System***

Make:	F.L.Smidth Tirax Ball Mill 3.2m x 5.5m + 1.8m RTKM 17.5 High Efficiency Separator
Motor Size:	Mill Motor – 630 kW Separator Motor – 30 kW
Capacity:	14 mtph at a product fineness of 5% retained on 90 microns

Simplicity and flexibility were the main design considerations for the fuel grinding system. Signal Mountain not only wanted the capability of grinding two fuels with different hardness, they wanted the ability to feed the calciner and kiln systems with different product fineness if necessary. For this reason, a one compartment ball mill was chosen to ensure the hard to grind petcoke could be accommodated. Also included in the system's design is two pulverized fuel storage bins, allowing for the conveying of product to either the calciner or kiln.



The closed grinding circuit consists of the ball mill and a high efficiency classifier. Drying is achieved through the introduction of cooler vent gases to the drying chamber, which is attached directly to the ball mill. Cooler vent gases and bleed air simultaneously control the mill exit temperature along with the mill inlet pressure. The mill is swept through the separator and vented to a dust collector.

PERFORMANCE RESULTS

TABLE 4 shows

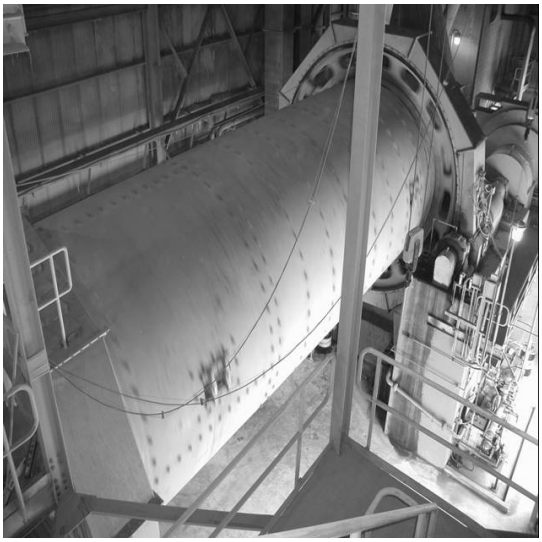
CONDITION	GUARANTEED RESULT	ACHIEVED RESULT
Production (mtph)	14	15.6
Product fineness	5% retained on 90µ	2.6% retained on 90µ
Feed Moisture	<11%	5.6%
Product Moisture	0.5%	0.5%
Power Consumption (kWh/mt)	38.0 (Ball Mill and Separator Motors)	35.0

TABLE 4: Fuel Grinding Mill Performance Results

- ***Finish Grinding System***

Make: F.L.Smidth 4.6m x 13.5m Fuller Traylor Mill
N-2500 O-Sepa High Efficiency Separator
10' x 20'8" FLS Product Cooler
Motor Size: Mill - 4500 kW
Separator – 225 kW
Capacity: 110 mtph at a product fineness of 3700 Blaine

The design of the finish grinding system provides a simple to operate mill that is also flexible, providing for the production of several cement products. The system consists of a two compartment ball mill and a high efficiency separator, each with a separate vent for easy operation. Product from the separator is conveyed through a cylindrical cement cooler to reduce the final product temperature to less than 70°C.



Cement product is then pneumatically conveyed to the existing cement silos and to the new barge loading station on the Tennessee River.

During commissioning, it was noticed that Signal Mountain's desired strengths were being achieved with a lower than guaranteed Blaine. Although the system was designed to produce 3700 Blaine product, the plant found that they could maintain the same product strength while producing cement with a product fineness of 3500 Blaine. This not only reduced their power consumption, but increased the production rate. ***TABLE 5*** summarizes the mill system's results:

CONDITION	GUARANTEED RESULT	ACHIEVED RESULT
Production (mtph)	110	129 (115)
Blaine	3700	3460 (3700)
Power Consumption (kWh/mt)	38.0	35.4 (38.6)
Cement Temperature	65ºC	68ºC
Initial Vicat Set Time	<150 minutes	110 minutes

TABLE 5: Finish Mill Performance Results

The plant supplied to Signal Mountain consisted of new equipment from the quarry to the finish grinding system. The plant was successfully commissioned in a reasonable time frame, with the integral success being between the Signal Mountain's personnel and the many vendors. With all the equipment designed according to the latest technology, Signal Mountain was able to exceed rated production, while continuously maintaining an efficient operation and minimizing the impact on the environment.

CONCLUSION

Managing an "owner directed" project such as the Signal Mountain plant places the majority of risk on the owner; however it also gives the owner the control over the project. Particular attention was always given to the plant aesthetics and functionality which are best controlled by the operators of the plant. This approach was not always without problems although having total control of the project allowed us to minimize the impact of these problems.

We are very proud of our new plant and we cannot say enough to thank all of the people involved. Coordination of all of these activities could not have been accomplished without the help and patience of the many suppliers and the dedication of the people involved.