A DECADE OF VRM PROGRESS FOR LOESCHE

LOESCHE VERTICAL ROLLER MILLS FOR CEMENT GRINDING - A PERFECT SOLUTION

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Over the last decade, ever since the first Loesche vertical roller mill for cement and slag grinding was installed at the Pu-Shin plant of Lucky Cement in Taiwan, the modular concept, reliability and low specific energy requirements of Loesche's mills have persuaded many producers to adopt the technology. This paper gives an overview of the technology involved, and then focuses on case studies in India, where the first-ever six-roller mills in the world - of type LM 56.3+3 CS - are currently under order for OCL and DCBL.

The health of a cement plant and its profitability is directly linked to the productivity of the cement grinding department and its ability to deliver quality product that meets the market dynamics. An ideal cement grinding system is one which consumes the lowest specific power consumption, gives trouble free operation, ensures adequate availability and is versatile enough to adopt to the market demands.

Some of the most important attributes of a grinding system that would make a perfectly profitable solution are the following:

- Simple & compact layout;
- Ease of both operation and maintenance;
- Lowest power consumption and operating cost;
- Availability of the mill including auxiliaries;
- Consistency in product quality;
- Proven technology and reliability;
- Flexibility to produce different qualities of cement to meet varying market demands;
- Availability of technical support and services.

Loesche vertical roller mills have demonstrated over the years that it is a preferred technology for raw material and coal grinding in the cement industry. Its lower power consumption compared to other systems, its reliability and ability to handle different types of feed materials of varying moisture content and other physical characteristics are accepted by the cement industry the world over.

Attempts have been made to use the four-roller vertical mills for clinker/slag grinding to make the most of the inherent advantages of a conventional Loesche mill. However, its applicability was restricted due to mill vibrations at higher finenesses, as well as apprehensions concerning the product quality.

Loesche mill LM 2+2 C/S

Subsequent intensive research by Loesche resulted in its new vertical roller mills 'LM 2+2' for cement and slag grinding. The application of the high specific force required for clinker and slag grinding was made possible by the carefully controlled formation of the grinding bed. One pair of small rollers (S-roller) de-aerates and pre-compacts the material to form a proper, stable grinding bed. The other pair of large rollers (M-roller) transmits the grinding force to perform efficient inter-particle comminution.

The basic concept of grinding in the 'parallel gap' between the conical roller and the flat table allows a very thin but stable bed thickness, leading to effective transmission of the high specific force required for creating super-fine cement of high quality with low specific power consumption.

The first such mill, an LM 46.2+2 C/S, started operation in December 1994 in the Pu-Shin plant of Lucky Cement in Taiwan. It achieved its capacity requirements of 500,000t/year OPC at 3600 cm^2/g and 250,000t/year granulated blast furnace slag at 4300cm^2/g. Thanks to the preparation of a stable grinding bed by the S-roller before the application of high specific force under the M-roller, there was little vibration in the mill operation. The quality of the cement was comparable or even better than that produced in the ball mill. Since then, vertical roller mills for clinker and slag grinding have been accepted as a proven technology. In fact, after the successful operation of its plant, Lucky Cement repeated an order for LM 46.2+2 C/S for its plant in Philippines.

Within a decade of the commissioning of the first Loesche clinker LM 2+2 mill, it has proved beyond

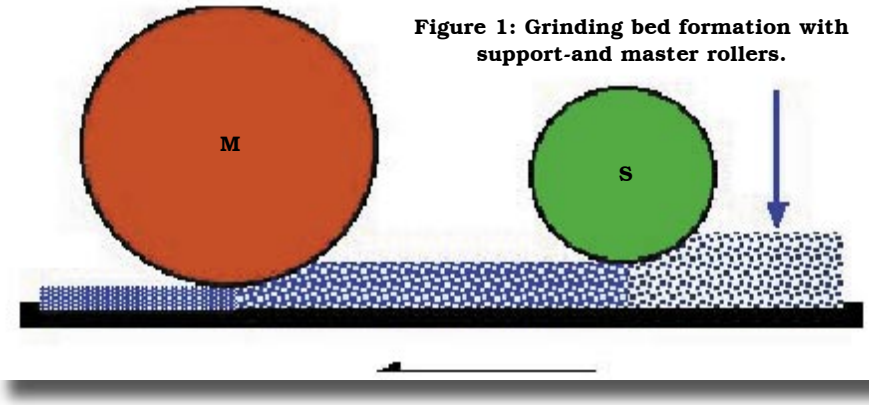


Figure 1: Grinding bed formation with support-and master rollers.

doubt to be a perfect solution for clinker grinding, due to its low specific power consumption, ease of operation and adaptability to various feed materials.

Today 51 mills with the 'LM 2+2' technology are in operation or under various stages of erection and commissioning. In India, the first such mill, an LM 46.2+2 CS, was commissioned in 1997 at OCL, Rajgangpur for grinding slag and clinker. This was followed by another LM 46.2+2 CS at DCBL, Dalmiapuram for a similar application. Today there is a total of six Loesche vertical roller mills (four of type LM 46. 2+2 CS and one each of LM 56.2+2 CS and LM 35. 2+2 CS) operational in India, producing various cements qualities OPC, PPC, PSC of varying fineness.

Indian orders

Additionally, two more clinker mills - for the first ever six-roller mills in the world - of type LM 56.3+3 CS are under supply to OCL India Limited at Rajgangpur and Dalmia Cement (Bharat) Limited at Dalmiapuram in India. It is worth mentioning here that all Loesche clients in India who have ever operated a Loesche mill for clinker/slag grinding have subsequently chosen the Loesche mill again - either of same size or a bigger one - for their new capacity requirements.

The salient design features of the LM 56.3+3 CS mills under supply are described below. Their operating experience with the LM 46.2+2 CS for grinding clinker and slag is also discussed in this article.

LM 56.3+3 CS mill

OCL India Ltd. has been successfully operating two LM 46.2+2 CS mills for the production of various types of blended cements. To meet additional capacity requirements due to the upgradation of the kiln, OCL decided to increase its cement grinding capacity by about 70% compared to the existing capacity, which is about 20% higher than the largest operational vertical cement grinding mill. Various alternatives including two LM 46.2+2 CS mills were evaluated to find the best techno-commercial solution for meeting the capacity requirement. After detailed deliberations and evaluation of the risk, OCL not only decided to choose a Loesche clinker vertical mill but decided to order the first ever six-roller Loesche Mill LM 56.3+3, tailor-made to meet all the capacity requirements.

Specification	Unit	
Gas volume flow rate	m^3/h	650,000
Pressure drop mill	mbar	50
Fan motor power	kW (rpm)	2500 (1000)
Classifier size		LSKS 87 CS
Table diameter	m	5.6
No. of rollers		M=3, S=3
Mill motor	kW	5300

Table 1 : Technical specifications of the LM 56.3+3 CS for clinker and slag.

The important criteria for the decision were the following:

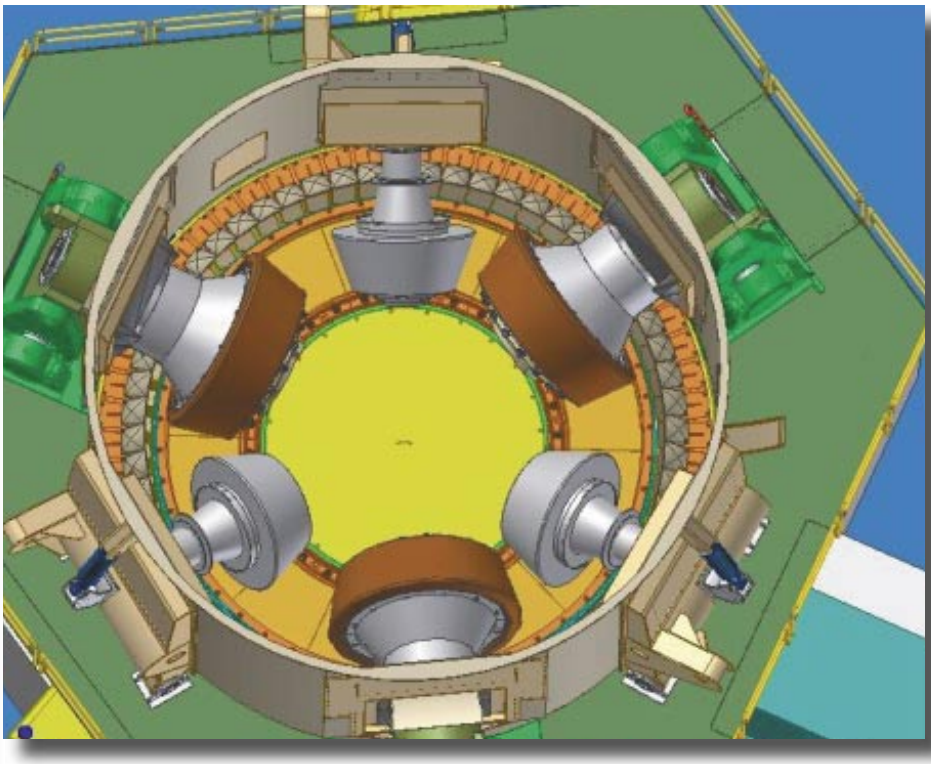
1. The nominal capacity of the LM 56.3+3 C/S mill should be tailor-made to meet the projected capacity requirement of OCL.

2. The project cost and maintenance cost should be less than that of two LM 46.2+2 mills. Furthermore, a single large mill would require less space which is an added advantage considering the layout constraints at the site.

3. Due to the basic modular design feature of Loesche mill, all the critical components of the LM 56.3+3 mill including the grinding rollers, hydraulic system should be selected from the standard elements which are of reliable design and proven in various installations.

4. The most important criterion was the confidence of the client in Loesche technology and its services based on the client's past experience with its two own Loesche clinker mills.

Figure 2: Arrangement of the three master and three slave rollers in the LM 56.3 3+3 CS mill.



Modular design

The Loesche mills are designed on the principle of modules, where a 'module' is a grinding element consisting of a pedestal with a bearing block, rocker arm, grinding roller and hydro-pneumatic spring system. This unit principle has been proven in all medium- and large-sized Loesche mills for raw material as well as for coal grinding since 1970. The modular design principle of Loesche mills allows the flexibility to use the proven and reliable components for development of a new mill. The modules are arranged around the table in a combination of two, three, four or six, depending on the capacity

requirement. The units can also be tailor-made to suit the user's capacity requirement.

The same principle of modular design has been adopted for clinker grinding as well. Therefore, in the Loesche clinker mills, dynamic and critical parts can be selected from pre-existing modules. It also gives the possibility of developing new and bigger sizes without the risk of unknown critical components.

Design features

The new LM 56.3+3 CS with a nominal capacity of more than 200t/h is equipped with three pairs of S- and M-rollers which have been installed and field-proven over the years in the smaller-sized mills of type LM 46 CS under a 2+2 roller arrangement. Therefore the main and dynamically loaded parts, such as rollers, rocker arms, spring systems and roller bearings have not had to be redeveloped again. The large mill table casting will be identical to those installed under the LM 56 CS with a `2+2' roller arrangement and already delivered several times. Only the static parts have to be designed in accordance to Loesche's experience and design standards.

To achieve sufficient stiffness in the mill stand against bending torsion, the LM 56.3+3 CS will be equipped with three pedestals under the Master-rollers. These pedestals will be connected by bridges at the top and a frame on the lower end. The distance between the pedestals allows the installation of two large gas ducts to the ring channel. The design and arrangement of these gas ducts were optimised by Loesche's fluid simulations, and they guarantee high efficiency in gas distribution of the gas flow for drying and transportation of the mill product and a low pressure loss in the mill inlet.

Maintenance work on the gearbox can be easily undertaken due to the large distance between the pedestals.

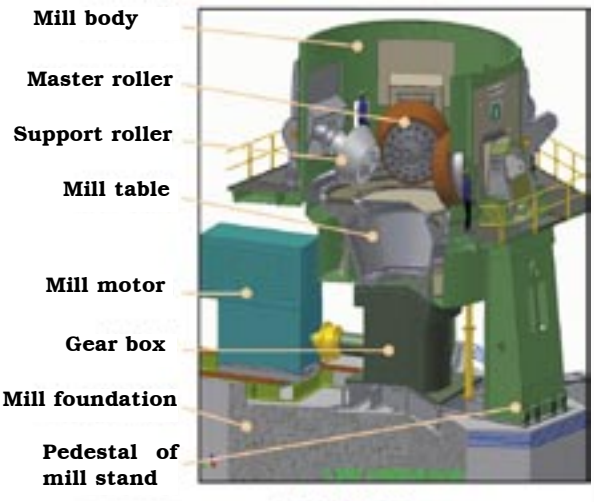
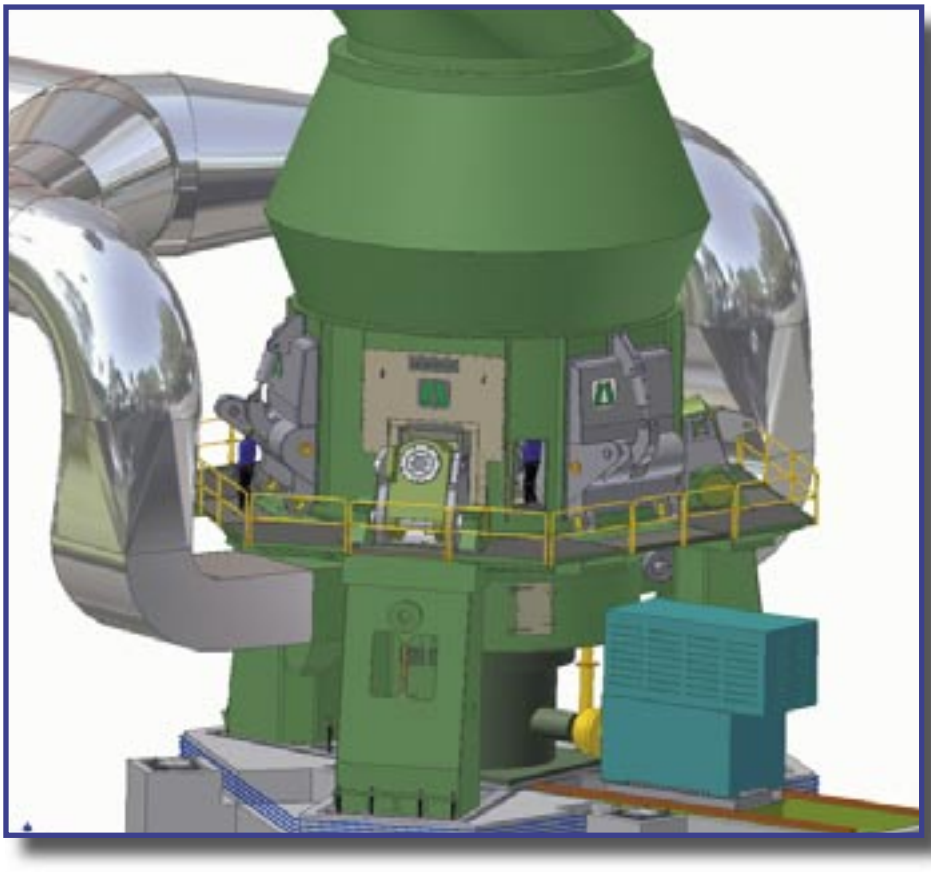


Figure 4: Schematic showing the internal layout of the LM 56.3+3 mill.

Figure 3: The Loesche Mill LM 56.3+3 CS. Note the three main pedestals, and the slave rollers positioned on the cylindrical mill body. Note also the two large gas ducts, on either side of the mill.



The S-rollers will be fixed to the cylindrical mill body which surrounds the grinding chamber. The diameter of the mill body is also optimised by CFD-simulation of the gas and particle flow inside the mill, to avoid unnecessary internal circulation.

The hydraulic spring system for converting the necessary hydraulic pressure into mechanical pressure at the grinding bed was changed over to twin-cylinder systems for all medium- and large-sized Loesche mills. This system - with a better relation of displaced oil volume and area through which it flows - leads to less risk of cavitation and minimises the chances of seal failures inside the hydraulic cylinders, in turn improving the mill availability. The design is also to be adopted for the new LM 56.3+3 mill.

The proven and well-known swinging-out system for the S- and M-rollers of the 2+2-mills can also be used for the LM 56.3+3 CS, for the fast exchange of worn-out grinding parts. The existing gearbox design of the LM 56 CS with the 2+2-roller arrangement can also be used for the new LM 56 CS with 3+3-rollers (Figure 4).

On top of the mill will be located the well-proven high efficiency LSKS-type classifier with static flaps and cage wheel in a special size suitable for the gas flow. A frequency-controlled motor is provided for infinite variation of the classifier speed. The efficient classifier prevents,

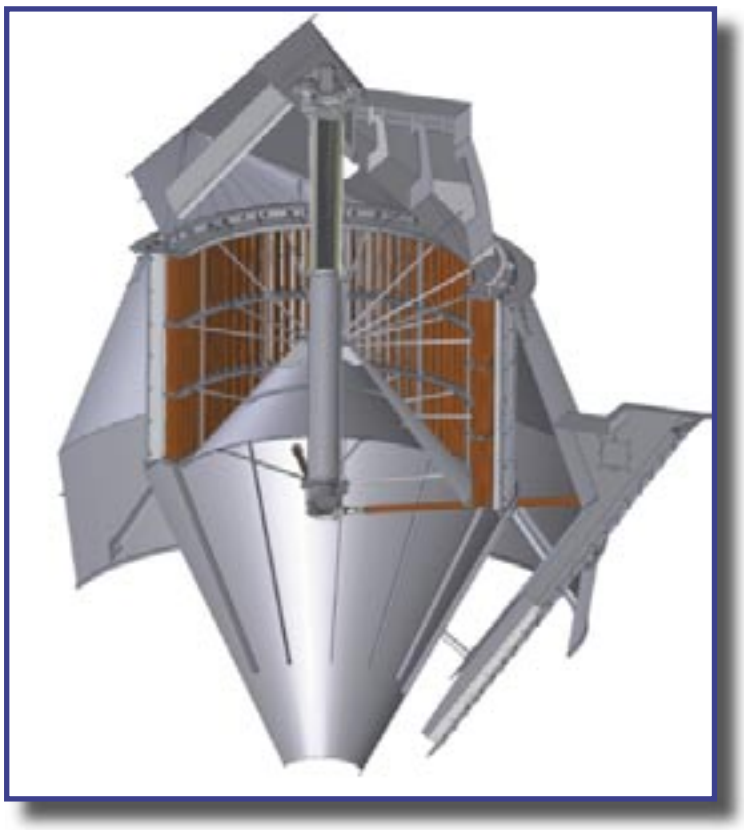


Figure 5: The LSKS high efficiency classifier.

Table 2	DCBL		OCL	
Type of cement	Blaine (cm^2/g)	Output (t/h)	Blaine (cm^2/g)	Output (t/h)
OPC	2900	305	4000	178
OPC			4500	134
PPC	3400	305		
Slag			5000	100
Slag			5500	88

above all, fines from being returned to the grinding table which essentially contributes to smooth running of the mill (Figure 5). The particle size distribution of the finished product can be influenced via the volume flow and the grinding pressure, as well as by changing the speed of the cage-wheel.

The axles and the rollers are identical to the same module in the LM 46.2+2, where the forces are slightly higher because of the higher grinding speed. This interchangeability reduces inventory cost of spare parts. Table 2 shows the guaranteed parameters for LM 56.3+3 CS.

Mill layout

Loesche clinker mills offer a very simple and compact layout. All the unit operations - drying, grinding and separation - occur in the mill itself and therefore the number of auxiliaries are limited to a minimum.

The feed material is transported to the mill through a rotary star feeder to avoid false air in the mill, which otherwise would load the fan and cause power loss. The star feeder is provided with heating in case of high moisture and sticky material. The wear parts in the star feeder can easily be changed.

All mills are equipped with a reject transport system. Material falling down to the gas ducts through the nozzle ring after leaving the grinding table rim is withdrawn from the mill by scrapers. In the case of slag, the reject mainly consists of iron particles which are present in the agglomerates of the granulated slag and which are separated during the grinding process. Those iron particles present in the reject are separated and removed by a magnetic separator to prevent its accumulation on the table. The dust-laden gas is dedusted through a pulse jet filter. A typical flowsheet for the mill is seen in Figure 6.

Operating experience

The first Loesche clinker/slag mill in India, the LM 46.2+2 CS, was commissioned at OCL Rajgangpur in 1997. It was designed for the grinding of clinker and slag separately

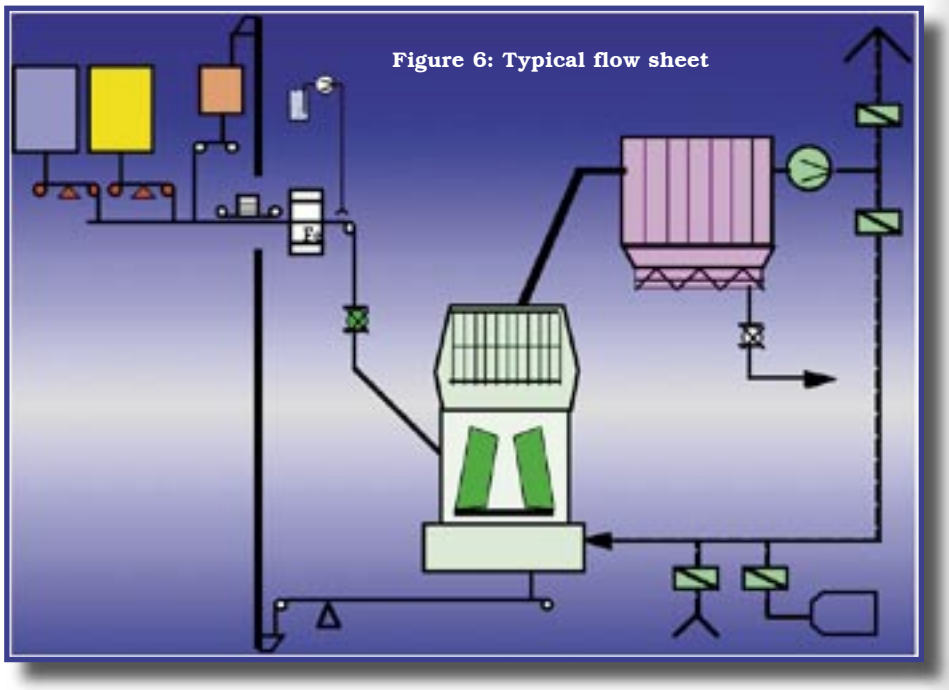


Figure 6: Typical flow sheet

Parameters	Unit	As in 1997		Guaranteed parameters after Classifier Modification					Remarks
		Slag	OPC	Slag	Slag	OPC	OPC	PPC	
Output	t/h	92	117	110	82	102	77	115	All performance parameters achieved
Fineness Blaine	cm^2/g	3400	3400	4000	4500	4000	4500	4200	

Table 3: Guaranteed capacity of the Loesche LM 46.2+@ C/S Line 1, at OCL Rajgangpur.

Parameters	Unit	Guaranteed parameters					Achieved parameters				
		Slag	Slag	OPC	OPC	PPC (Flyash)	Slag	Slag	OPC	OPC	PPC* (Flyash)
Output	t/h	110	82	102	77	115	113.90	101	103.4	78.70	
Fineness Blaine	cm^2/g	4000	4500	4000	4500	4200	4116	4514	4125	4605	
Power Consumption	kWh/t	-	38.8	36.8	-	34.3	35.37	39.11	33.62	41.40	
* No separate performance trial was conducted for PPC as better results were achieved during normal operation.											

Table 4: Operating results of the Loesche clinker mill LM 46.2+2 C/S, Line - 2

and then mixing as well as grinding them together (inter-grinding) without having to modify or adjust any of the mill internals. The successful commissioning and meeting all the expectations of the client with respect to its flexibility, reliability and ease of operation, in addition to the guaranteed parameters, was an important milestone and has won the confidence of OCL. All the apprehensions regarding the quality of cement ground in vertical roller mill were put to rest and OCL could launch different product mixes of superior quality.

Subsequently OCL undertook further modifications and optimisation of the mill which lead to much improved operating results. The original LDKS type classifier was replaced with a cage wheel LSKS-type classifier, resulting in about 10% increase in capacity. In 2002, the classifier was again replaced with the latest design of LSKS-type Loesche high efficiency classifier, to achieve higher fineness and reduced specific power consumption. A comparison of the guaranteed mill capacity as originally supplied and after the LSKS classifier in 2002 is given Table 3.

Based on its experience with the line No.1 mill, OCL placed a repeat order with Loesche for another LM 46.2+2 CS mill. The second mill was commissioned in 2002 and met all the performance guarantee parameters in terms of output, specific power consumption, and fineness for different products. Apart from those normal guarantee parameters, an additional guarantee of a minimum of 550hours/month of mill availability for six consecutive months from commissioning was also achieved. Thanks to the untiring effort and co-operation of OCL team, Loesche fulfilled all the guarantee obligations including mill stability and availability.

The guarantees and actual operating results for the performance trials for the second LM 46.2+2 CS mill are given in Table 4.

Both the mills have been in successful operation since their commissioning for grinding clinker, slag and even Portland pozzolana cement of varying finenesses and quality. The change-over from one product to another can be achieved with ease by changing operating parameters from the central control room, without having to modify or adjust any of the mill internals. The stability and adaptability of the mill to handle different feed materials, varying in their moisture and feed size has also been established.

As a result of the improved product quality, slag absorption in slag cement has been enhanced. The capacity of the plant has been increased from the original 0.7Mt/year to 1Mt/year with installation of first mill and later to 1.3Mt/year after the second mill, without increasing the clinkerisation capacity.

Table 5 shows some of the performance figures with respect to different product qualities and fineness achieved during various trials in the

Table 5: Operating results of trials on the LM 46.2+2 C/S mill at OCL.

Product	Clinker	Gypsum	Slag	Flyash	Spec. surface (Blaine)	Output
OPC	95%	5%			3000 cm^2/g	120 t/h
OPC	95%	5%			4000 cm^2/g	100 t/h
OPC	95%	5%			4500 cm^2/g	77 t/h
Slag		10%	90%		3500 cm^2/g	120 t/h
Slag			100%		4500 cm^2/g	85 t/h
Slag			100%		5000 cm^2/g	65 t/h
Slag			100%		5500 cm^2/g	60 t/h
PPC	70%	5%		25%	4300 cm^2/g	147 t/h
PSC	40%	4%	56%		3650 cm^2/g	132 t/h

Figure 7: Overview of the DCBL plant at Dalmiapuram, India.

LM 46.2+2 CS mills at Rajgangpur.

Apart from the ease of operation and maintenance, other salient features of the experience at OCL are:

• Flexibility to customise the product without having to make any internal changes;

• Saving in specific power consumption of about 16kWh/t at 3400 blaine in case of slag cement compared to ball mill. Saving would be even greater at higher blaines.

• Initially grinding aid up to 200g/tonne was being used for clinker grinding though no grinding aid was used in case of slag. The grinding aid consumption was continuously optimised. Introduction of water sprinkling onto the grinding bed enabled grinding of hot clinker as well as partly substituting the requirement for grinding aid. The mill could be operated smoothly for OPC at 4500 blaine without grinding aid addition.

• Better utilisation of waste material resulted in the extension of the life of the limestone mine. Utilisation of additional 0.7Mt/year of slag/fly ash would have resulted in a reduction of about 0.6Mt/year of CO_2 emissions.

Experience at DCBL

The LM 46 2+2 CS at Dalmiapuram was commissioned in 1997 and since then it has been in successful operation. Originally the mill was guaranteed for 120t/hour at 3400 blaine OPC and 90t/hour at 3400 blaine guaranteed blast furnace slag. However, due to logistical reasons, nowadays, slag is not ground and instead various grades of OPC and PPC with 25 – 28% flyash are produced. The mill operation is very smooth, with vibration levels of only 2 to 3mm/sec measured at the mill body. The LDKS classifier was replaced with an LSKS 66 high-efficiency classifier. Coupled with classifier retrofitting and other optimisations, this has resulted in further improvement of the mill performance.

The mill performance data before and after modification LSKS classifier modification is given in Table 6, below.

The classifier modification resulted in an increase of 25% in output and a saving of 3 to 7 kWh/t of cement depending on the type of cement. The saving in power alone after the classifier modification resulted in a cost saving of approximately US$0.5m/year.

The availability and reliability of the Loesche LM 46.2+2 CS mill has been excellent. Based on its experience of the mill and their confidence in Loesche, DCBL ordered the largest clinker mill LM 56.3+3 CS for its new line.

To date, seven mills of the type LM 56.3+3 CS have been sold to customers in India, China and others.

Conclusion

Over the last ten years, since the successful commissioning of the first Loesche mill at Pu-Shin, Loesche clinker mills have been proven as a perfect cement grinding technology around the world. The reliability and flexibility of the mills are well accepted. The mills have a simple and compact layout and are easy to operate and maintain. Their low specific power consumption combined with high availability make Loesche vertical roller mills a perfect solution for clinker grinding. ***GCL***

Table 6 : Mill performance data before and after LSKS classifier modification

Description	Unit	LDKS 95 (Before)		LSKS 66 (After)	
		OPC 43	PPC	OPC 43	PPC
Fineness	Blaine	2800-2900	3450-3500	2800-2900	3450-3500
Mill Output	t/h	155-165	135-140	200-205	170 -184
	% increase	-	-	25.8	25.9
Specific power consumption	kWh/t cement	22.6	29.6	20.0	22.0
	% reduction	-	-	12.4	25.2

This article is based on a presentation given at the 3rd Asian Cement Conference, Mumbai, October 2004.