Development of 6-Roller UBE Vertical Mill for Slag / Cement Grinding
&
Modular Design Concept for UBE Vertical Roller Mills (VRMs)
for Large Cement Plants

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This paper introduces the development of the UBE 6-Roller VRM, which achieves higher Milling Performance at better Cost-Performance, to meet client demand for higher Energy Efficiency and Yokozuna size(*) Mill Capacity for increasing Cement Plant capacity. Other advantages include greater Reliability and easier Maintenance due to greater parts commonality and rationalization for the VRM range, achieved by the new Modular Design Concept.

(*) Yokozuna is the great champion of Sumo wrestling.

1. Introduction

As a result of the world-wide attention in recent years to Energy Efficiency Improvement and CO_2 Reduction, the numbers of VRMs adopted for Slag / Cement grinding are increasing. And effective use of granulated blast furnace Slag has been widely promoted, resulting in further VRM demand for Slag Grinding. More demand for Slag Grinding VRMs is anticipated in developing countries, too, where the trend is to adopt Large Plant Capacity (5,000 - 10,000 t/day) to meet strong market demand for cement. To meet the increase in plant capacity, demand for greater milling capacity Vertical Mills is also growing rapidly.

Under this background, UBE has developed a new 6-roller Slag / Cement Mill suitably designed for capacity maximization, higher efficiency and lower cost compared to the conventional VRM. The First Development Mill (UM43.6SR) started commercial operation in March 2013, with excellent performance results as presented in this paper.

Further, with the recent increase in Cement Plant Capacity, larger milling capacity is required. To meet this increased plant capacity demand, UBE introduces the new Modular Design Concept, which increases reliability through commonality of mill parts, and achieves reduced maintenance cost.

2. Development of New Type Slag / Cement Mill

Product Fineness of Slag / Cement powder is ultrafine (Dp50 = approx. 10 - 15μm), and the occurrence of vibration can interfere with stable Mill operation. The essential countermeasure to suppress mill vibration is to increase (improve) friction coefficient of material in the grinding area directly beneath the mill roller.

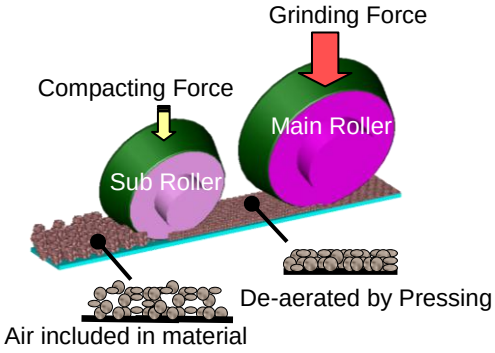


Fig.1 Principle of 2-Way System

In the 1980s, UBE developed the 2-Way System shown in Fig. 1, where de-aeration and compaction of the raw material bed on the grinding table by sub-roller pressing is achieved, improving the material coefficient of friction.

The Test Results shown in Fig. 2 demonstrate that the higher the degree of grinding bed compaction, the higher the value of the Material Friction Coefficient.

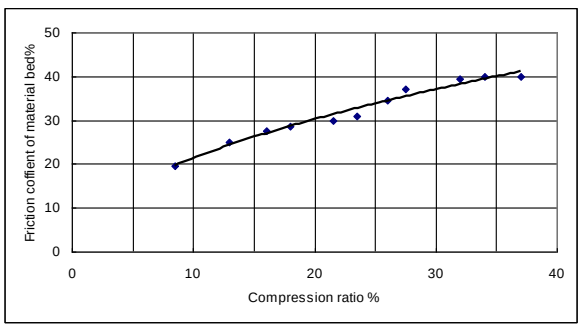


Fig.2 Compaction Degree of Grinding Bed vs. Friction Coefficient of Material

UBE performed further research to investigate the relationship between Degree of Compaction & Friction Coefficient, and found a link between grinding bed depth and Friction Coefficient of material bed. Fig.3 demonstrates that the shallower the grinding bed, the higher the Friction Coefficient of material bed.

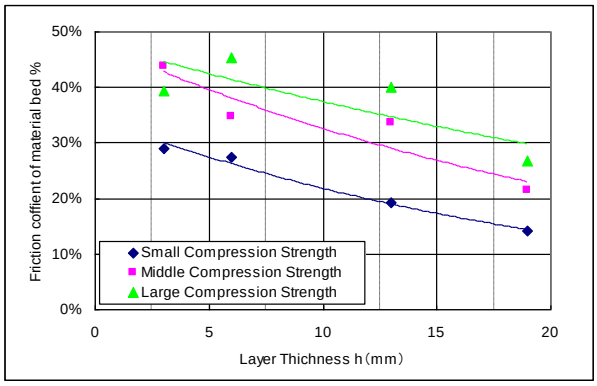


Fig.3 Measuring results for Friction coefficient of material bed

This test result, clearly demonstrating the relationship between bed depth and Friction Coefficient (Fig.3), inspired UBE's decision to develop a new VRM with smaller rollers but larger capacity than ever before.

By adopting smaller grinding rollers, theoretical mill capacity is decreased, but by increasing the number of rollers from 4 to 6-rollers, mill capacity is maintained. Moreover, as the new 6-Roller Mill employs the 2-Way System, and the support structure of the new, low-load Sub-Roller configuration has also been refined, mill weight and cost are reduced, while the same mill performance as a larger mill is achieved. Accordingly, a new concept, down-sized mill has been successfully developed.

2.1. Results of Development

2.1.1 Comparison of Specification and Cost of Mill

Table.1 is a Specification Comparison of Conventional & newly Developed Mill.

Note: Table 1 presents performance figures for a representative mill (Slag Grinding Capacity: 90 T/H, Clinker Grinding Capacity: 120 T/H), where mills of the same model achieve very similar production results.

The new 6-roller Mill's greatest advantage is Mill down-sizing. By combinations of Table size, Roller size and number of Rollers, Mill down-sizing has been achieved relative to the conventional mill of same mill capacity. In the case of 'Table 1', the conventional mill is a UM46.4SN（table diameter: 4,600 mm）, while the new mill is a UM43.6SR (table dia: 4,300 mm), or one full model size smaller in terms of Table diameter.

In this case, by adopting the 6-roller mill with new design sub-rollers support, compared with the conventional UM46.4SN mill, a 20% reduction of mill weight was achieved. Moreover, as secondary effects of reduced mill weight, foundation concrete weight reduced by ▲20%, and Maintenance hoist crane capacity reduced by ▲40% when compared to a conventional mill. The reduction in concrete weight in particular has a considerable cost advantage in terms of initial investment.

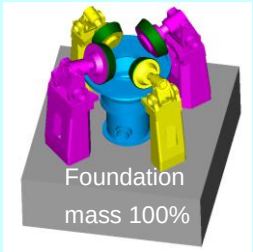
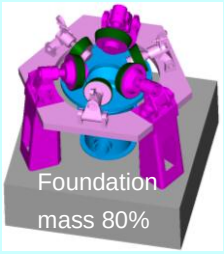
		Conventional Mill	Development Mill
Mil Type		UM46.4SCN	UM43.6SCR
Table Dia.		φ4600mm	Φ4300mm
Main Roller	Dia.	φ2240mm	φ1800mm
	Q'ty	2 pcs	3 pcs
Sub Roller	Dia.	φ1700mm	φ1120mm
	Q'ty	2 pcs	3 pcs
Mill Weight		100%	80% (▲20%)
Others		 Crane 100% 	 Crane 60% 

Table 1 Comparison of Specification and Cost (Slag 90T/H, Clinker 120T/H base)

2.1.2 Performance of UM43.6SR

An order for the first UM43.6SR Slag Mill was received from China, and mill trial operation started in December 2012. In March 2013 mill performance acceptance was completed.

Fig. 4 Slag Grinding Plant and 6 Roller Mill

Table 2 shows actual operation data comparison of UM46.4SN (Conventional Mill) & UM43.6SR (Development Mill)

		Conventional Mill	Development Mill	Difference
Mil Type		UM46.4SN	UM43.6SR	
Capacity		96T/H	99T/H	+3%
Fineness		4,200cm3/g	4,205cm3/g	
P.C.	Mill	25.3kW/t	24.9kW/t	
	Sep.	1.4kW/t	1.3kW/t	
	Fan	8.0kW/t	7.8kW/t	
P.C. Total		34.7kW/t	34.0kW/t	-2.0%
Vibration		25～50μm	15～35μm	
Remarks		After 1000h Operation	After 1000h Operation	

Table 2 Actual Operation Data of Slag Grinding

As per Table 2, the UM43.6SR Mill Capacity increased approximately 3%, and Power Consumption decreased about 2% compared to UM46.4SN. Superiority of the new UM43.6SR mill design is confirmed by this data.

Further, regarding mill vibration, which was another performance improvement target of this project, the new mill ran at lower vibration as expected. It may be assumed that this is a result of the shallower grinding bed depth and higher Coefficient of Friction in the new mill in comparison to the conventional mill. The reduced mill vibration and improved grinding efficiency have resulted in a significant performance improvement of the newly developed mill over the conventional mill.

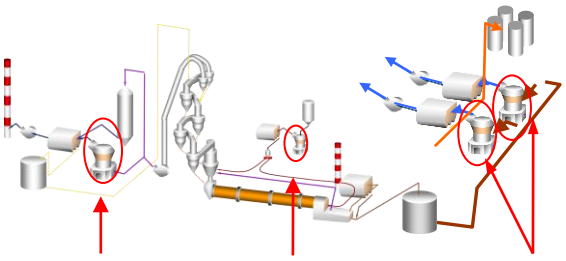
Accordingly, the first operating 6-Roller Slag Mill has achieved all of the mill performance targets established in the development stage, to the great satisfaction of the customer.

Furthermore, UBE has received an order for the same model UM43.6SCR Slag / Cement Mill for Australia, with mill scheduled to start operation in early 2014.

3. VRM Proposal for New Large-Capacity Cement Plants

Recently, with increasing Cement Plant Capacity, vertical mills are being used not only for raw material and coal grinding, but also for cement grinding.

Fig 5 shows a typical VRM arrangement for new cement plant.



1 Set of Raw Mill　1 Set of Coal Mill　2 Sets of Cement Mill

Fig.5 Typical VRM Arrangement for Large Cement Plants

The larger cement plant capacity becomes, the larger mill capacity must also become, and such over-sized VRMs require special engineering, and special parts and support machinery. Due to lack of common parts, in the event of mill breakdown, there is the risk of long term plant shut-down. Accordingly, the End User is faced with the dilemma of opposing requirements: Large Capacity Production and Security of Common Spares.

In order to reduce risk of long-term shutdown, Mill Users stock many key spare parts (for example: bearing, cylinder, etc.), however, maintaining a lot of spare parts stock for each different VRM is not good economics.

From this viewpoint, VRMs installed on new Cement Plants in recent years must not only have the characteristics of Large Capacity and High Efficiency (low power consumption), but also High Reliability with Low Initial Investment and Low Maintenance Cost.

In order to meet the above mentioned demands, UBE has conducted new research into a modular mill concept, and introduce herewith VRM combinations to meet of plant capacity with each mill size as follows.

3.1 Modular concept design

UBE has been designing the VRMs Rollers in accordance with Modular design concept. In other words, if roller size is same even for different table size, same roller assembly, same swing lever assembly and same tension device are used. By adopting this design method, parts standardization is achieved.

The following example is a combination of Raw Mill & Cement Mill suitable for new, large capacity Cement Plants, comprised of a 5-roller Raw VRM and 6-roller Cement VRM, having 2-way systems with small roller size. With this adaptation the mill is able to be down-sized and used for the large Cement Plant, while improving standardization of key parts and interchange ability, thereby improving reliability at a lower equipment cost. Details of this design method are as follows. (Please refer to Fig.6, 7 & Table3)

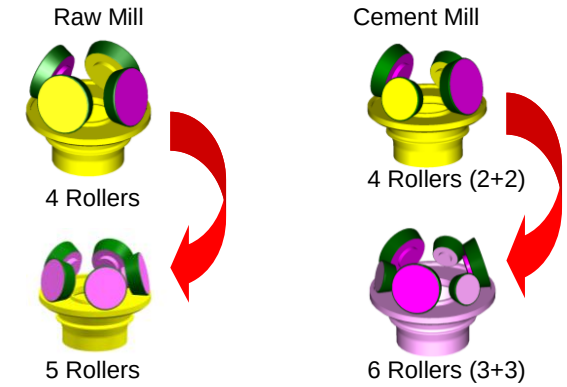


Fig 5– & 6–Roller Mill Design

By changing the conventional 4-roller design to the 5-roller raw mill, a 10% down-sizing was achieved, and by changing the conventional 4-roller cement mill to the new 6-roller mill, a 20% down-sizing was achieved while maintaining the same grinding capacity in both cases.

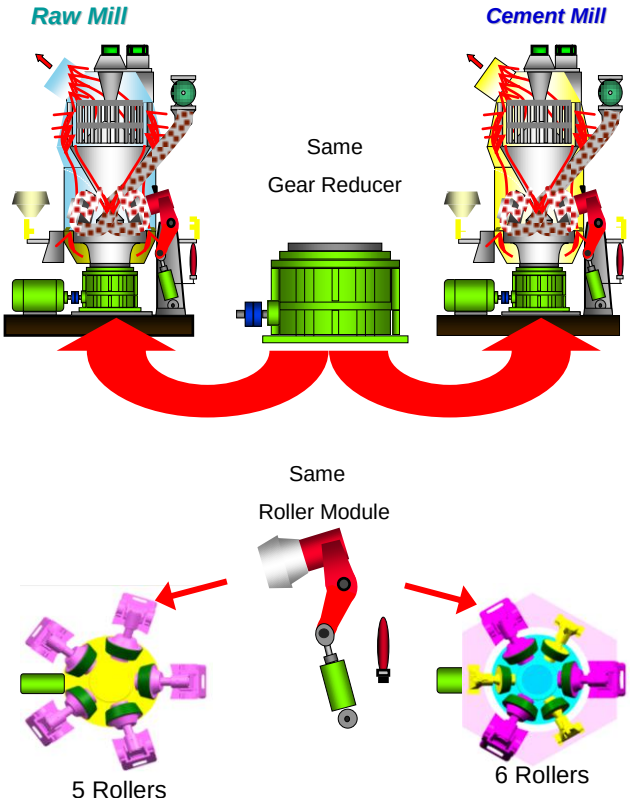


Fig.7 Modular Design Concept of VRM

As just described, by changing to smaller, modular roller mill design, the same grinding roller modules are

used for both raw and cement mills, and parts commonality is achieved.

Further, by matching mill power and table rotation speed, identical reduction gear units are used on the three VRM: (1) set of 5-roller raw mill, and two (2) sets of 6-roller cement mills.

3.2 Combination of mills for new, large cement plant

Table3 shows typical 'Mill sizing Table by Module Concept（Example）'.

Plant Capa.		Raw Mill (1 Set) 5 Roller Type	Cement Mill (2 Sets) 6 Roller Type
10,000 T/D	Mill Capacity	750 T/H	260 T/H x 2
	Mill Type	UM63.5	UM61.6 CR
	Roller Size	φ2500 x 5	φ2500 x 3 φ1900 x 3
	Reduction Gear	6,000kW 23.1rpm	6,000kW 23.1rpm
7,500 T/D	Mill Capacity	580 T/H	200 T/H x 2
	Mill Type	UM59.5	UM56.6 CR
	Roller Size	φ2240 x 5	φ2240 x 3 φ1700 x 3
	Reduction Gear	5,100kW 23.8pm	5,100kW 23.8rpm
5,000 T/D	Mill Capacity	400 T/H	150 T/H x 2
	Mill Type	UM53.5	UM50.6 CR
	Roller Size	φ1900 x 5	φ1900 x 3 φ1500 x 3
	Reduction Gear	3,800kW 26.7rpm	3,800kW 26.7rpm

Table 3 Mill sizing Table by Module Concept（Example）

3.3 Advantage of Module design concept

As per above-mentioned, by adopting small roller module, new concept VRMs are able to keep mill performance while down-sizing the mill, and the initial investment for the project is may be reduced.

And through standardization of parts, End Users can manage spare parts and trouble-shooting more easily, thereby ensuring mill availability and reliability. Due to commonality of spares, quantities of contingency spare parts can be reduced, so the cost burden for spares is also is lower.

4. Conclusion

UBE has supplied over 500 VRMs for Cement Plants, Slag Grinding Plants and other plants all over the world. From a strong experience base, UBE will continue to develop VRM technology in order to supply larger size, more energy efficient, better cost performing Vertical Roller Mill, while maintaining UBE's high quality standard.