National Council for Cement and Building Materials
(Under the Administrative Control of Ministry of Commerce & Industry, Govt. of India)
16th NCB International Seminar on Cement, Concrete and Building Materials
CLEAN & GREEN IS SUSTAINABLE
03 - 06 December, 2019 at Manekshaw Centre, Parade Road, New Delhi, INDIA

ENERGY EFFICIENT VRM TECHNOLOGY FOR CEMENT AND SLAG GRINDING

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Introduction

With the recent attention on environmentally friendly technology focused on CO_2 emission reduction and energy efficiency, the demand for Vertical Roller Mills (VRMs) in the cement market, especially for cement and slag grinding, has been increasing.

UBE Machinery Corporation, Ltd. (UBE) has a history of over 60 years in manufacturing VRMs. UBE has delivered over 540 VRMs throughout the world, including 20 units in India, and has received outstanding feedbacks from customers for its technology, ease of operation and maintenance, and energy efficiency. The technological developments in which UBE has focused on are "2-Way System" and its latest separator design, which realized efficiency in terms of both operation and energy.

UBE with an endeavor to offer its VRMs to the Indian cement market, which is expected to grow due to the Indian Government's policy of urbanization and improvements in housing and infrastructure, has begun technological collaboration with AMCL Machinery Ltd. (AMCL), which has been in the Vertical Roller Pre-Grinding Mill (VRPMs) business for the last 23 years.

The objective of cooperation between UBE and AMCL, along with some of the latest trends and data of the latest VRM will be shared in this paper.

Technical Collaboration with AMCL

In May 2019, UBE signed an exclusive License Agreement for the manufacture, sales, and after sales service of VRMs in India, Bangladesh, Nepal and Bhutan with AMCL. UBE and AMCL will cooperate to offer UBE's cultivated technology to India in an effective manner.

UBE is a subsidiary of UBE Industries, Ltd., a conglomerate operating in three main businesses: chemicals, construction materials, and machinery. The construction materials business, also known as the cement division of UBE Industries, Ltd., is one of the key players in the Japanese cement market with three cement plants in operation across Japan. UBE has delivered 14 of its own VRMs to these plants. The oldest of these VRMs, delivered in 1973, is still operating with no major issues owing to the periodical maintenances and technical innovations conducted by skilled engineers from UBE. What distinguishes UBE from other VRM manufacturers is the fact that UBE not only

manufacturers VRMs but also operates its VRMs in its cement factories. This is a benefit to UBE since UBE can receive direct feedback from its cement factories and make continuous improvements to its VRMs.

On the other hand, AMCL is a Group company of Hindusthan National Glass and Industries Ltd. (HNG), a leading manufacturer of container glass in India. AMCL, which originated as a joint venture company of ACC Ltd. and Leonh Herbert Machinenfabrik (Thyssen Group Company) of Germany, is a manufacturer of industrial machines including VRPMs and has its workshop conveniently located in Nagpur, center of India. AMCL has been supplying VRPMs, mainly to cement factories in India, and is well-experienced in both mechanical and process aspects of the cement manufacturing field. As a result, AMCL will have no issues in manufacturing VRMs. Furthermore, AMCL will install test mill facilities at its workshop to determine the grindability for raw materials, coal, clinker, slag, etc. This would go long way in assisting Indian customers.

UBE's VRMs for Cement and Slag Grinding

(1) 2-Way System

In order to improve energy efficiency, UBE has been putting efforts on sustained basis. In this connection, way back since 1980 when 2-Way System was developed for grinding cement and slag grinding systems as show in *Figure-1* where de-aeration and compaction of the raw material bed on the grinding table is achieved by sub-rollers pressing thereby improving the material friction coefficient. Due to this effect, the grinding rollers can suitably bite the material without slippage, allowing operation with minimized vibration. Over the years UBE has the well-established 2+2 and 3+3 system of Main Roller and Sub Roller for Cement and Slag grinding.

Moreover, one of the features of UBE's sub-rollers is their positioning. UBE's sub-rollers are designed to generate sufficient amount of load and, in order to activate the load properly on the material, the sub-rollers, along with the main-rollers, are positioned near the dam ring on the outer circumference of the table. As a result, with the counterforce from the dam ring, the air contained in the material can be deaerated efficiently and the material, along the dam ring, gets fed to the main-rollers precisely. Another feature of UBE's sub-rollers is the fixation of gap between the sub-rollers and the table with mechanical stoppers, which allows material of consistent height to be fed to the grinding rollers. This further contributes to stable operation.

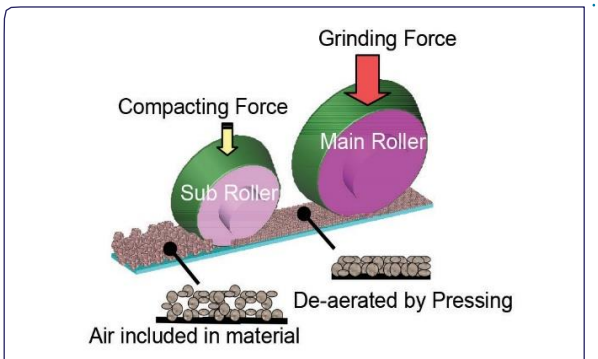


Figure 1. Principal of 2-Way System

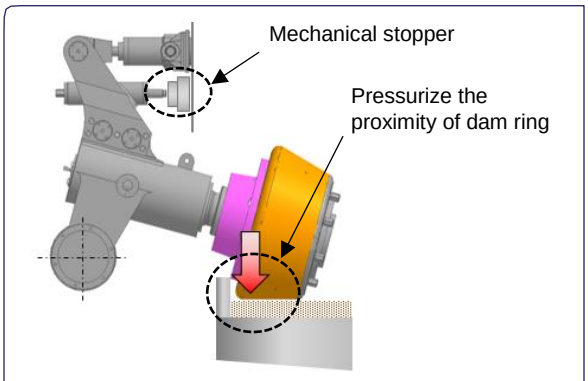


Figure 2. Construction of sub roller

(2) Latest Design – Separator

i. Conventional design

In recent years, UBE has been researching on obtaining ideal gas flow through gas flow analysis technology. *Figure 3* shows the gas flow analysis result (flow lines and velocity distribution) of the conventional design. In particular, in cross section Z=9m, there is an area where the speed of the gas flowing into the separator is fast. Furthermore, in Z=12m, in addition to the gas flowing in, there is uneven velocity within the separator. In other words, the analysis indicates an uneven gas flow inside the mill. If velocity occurs in the vicinity of the separator, the classified particle size distribution becomes either big or small in the circumferential direction of the separator. As a result, the increase in internal circulation causes an increase in mill differential pressure and decrease in capacity and power consumption, which leads to mill vibration. Furthermore, the deterioration in product quality becomes a concern from the widened particle size distribution. Additionally, uneven velocity within the mill can lead to abrasion, thus increasing maintenance cost.

By studying the analysis of the conventional design, UBE discovered that the uneven velocity flowing into the separator (Z=9m of *Figure 3*) is strongly impacted by the positioning of the mill inlet duct. Likewise, uneven velocity flowing out of the separator is strongly affected by the positioning of the duct and its design. As indicated by the flow lines in area Z=12m of *Figure 3*, fast gas flow occurs directly beneath the outlet duct.

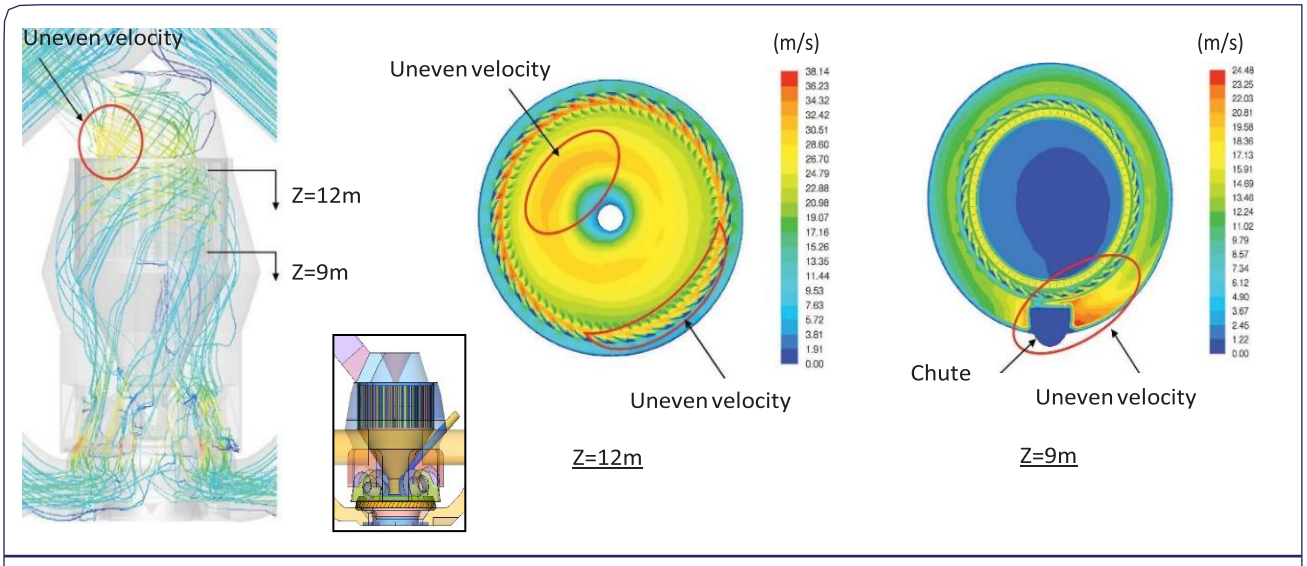


Figure 3. Gas flow analysis result of conventional design: Z=12m (left); Z=9m (right).

ii. Latest design

As a countermeasure for uneven velocity gas flowing into the separator, UBE installed a nozzle ring of ideal form to achieve optimized gas speed. To correct the uneven velocity gas flowing out of the separator, UBE designed a unique separator, as shown in *Figure 5*. The distinctive feature of this design is the decentering of the outlet duct from the separator. By decentering the duct from the center of separator to X, Y direction, it was possible to suppress the fast gas flow directly beneath the duct and smoothen the discharge of revolving airflow from the separator (*Figure 5*).

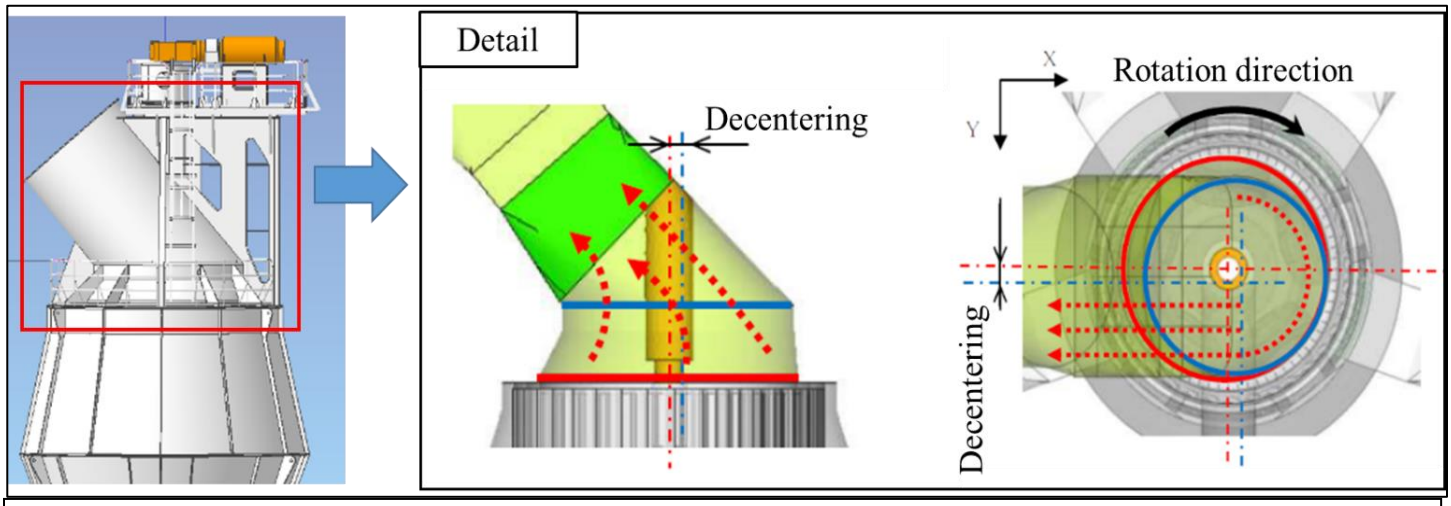


Figure 5. Latest design of the Separator.

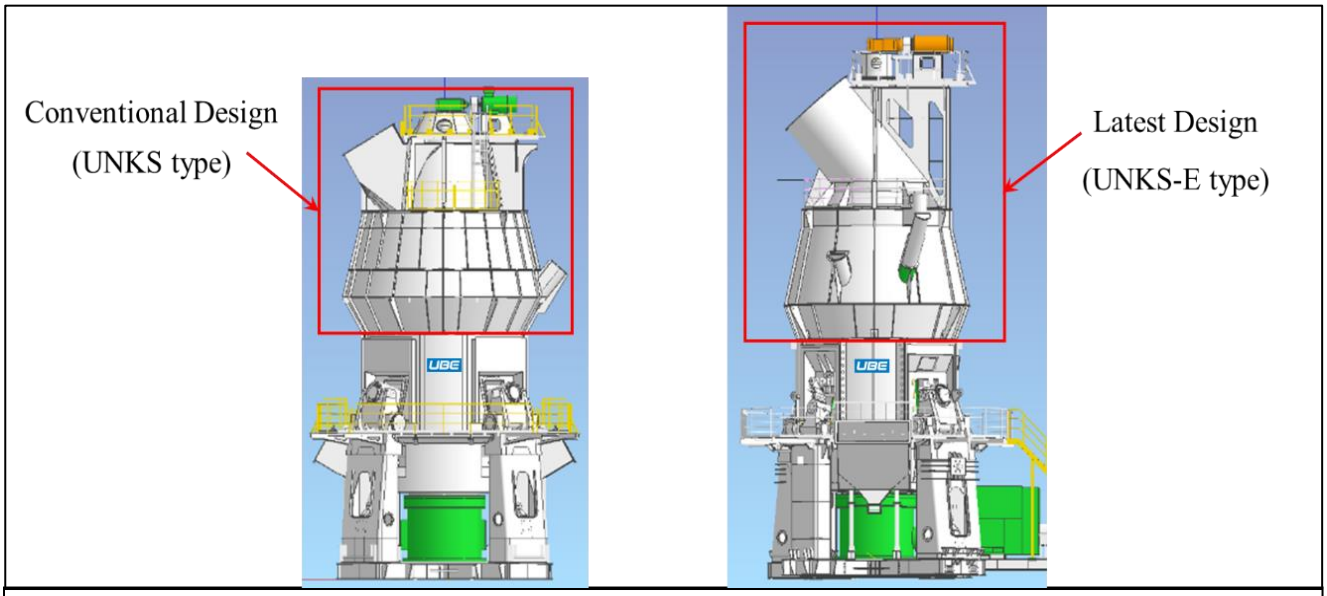


Figure 4. Comparison between conventional design and latest design of Separator.

Figure 6 and 7 shows the comparison of gas flow analysis result (flow line, velocity distribution) between conventional and latest design of separator. By installing a nozzle ring of ideal design, the gas flowing into the separator became smoother in comparison to the conventional design. Furthermore, for the gas flowing out of the separator to the outlet duct, uneven velocity was fixed by decentering the outlet duct to allow even discharge of gas in circumferential direction.

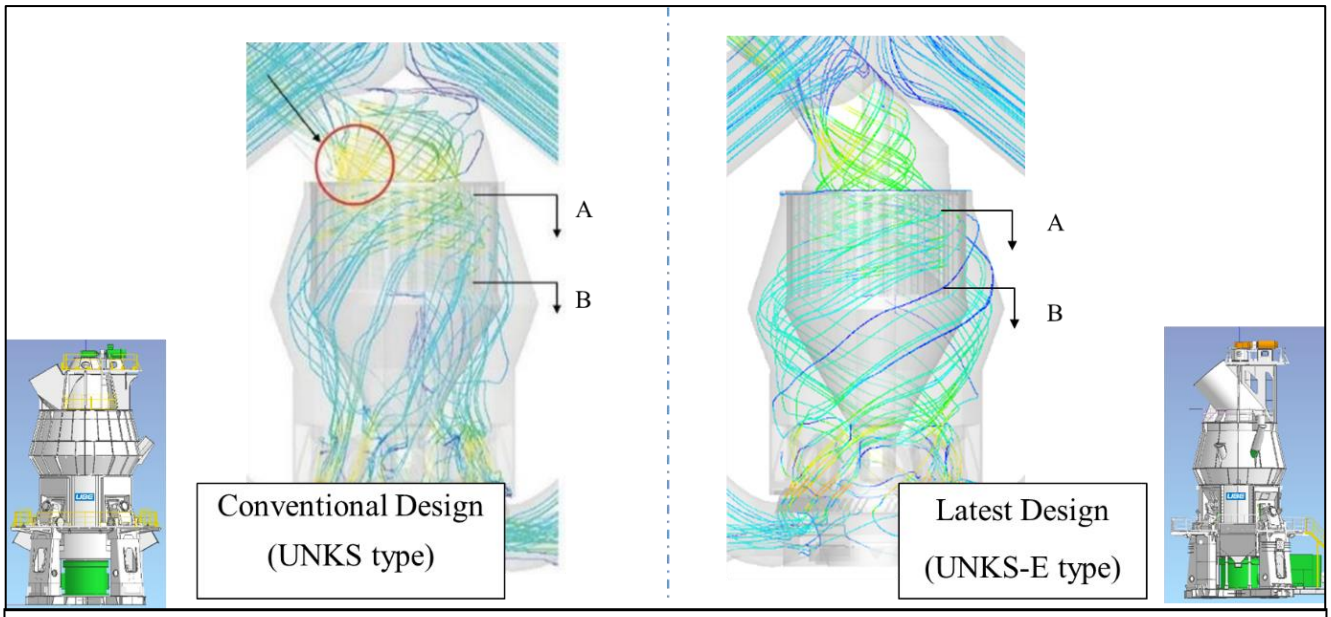


Figure 6. Comparison of Gas flow analysis result between Conventional and latest design.

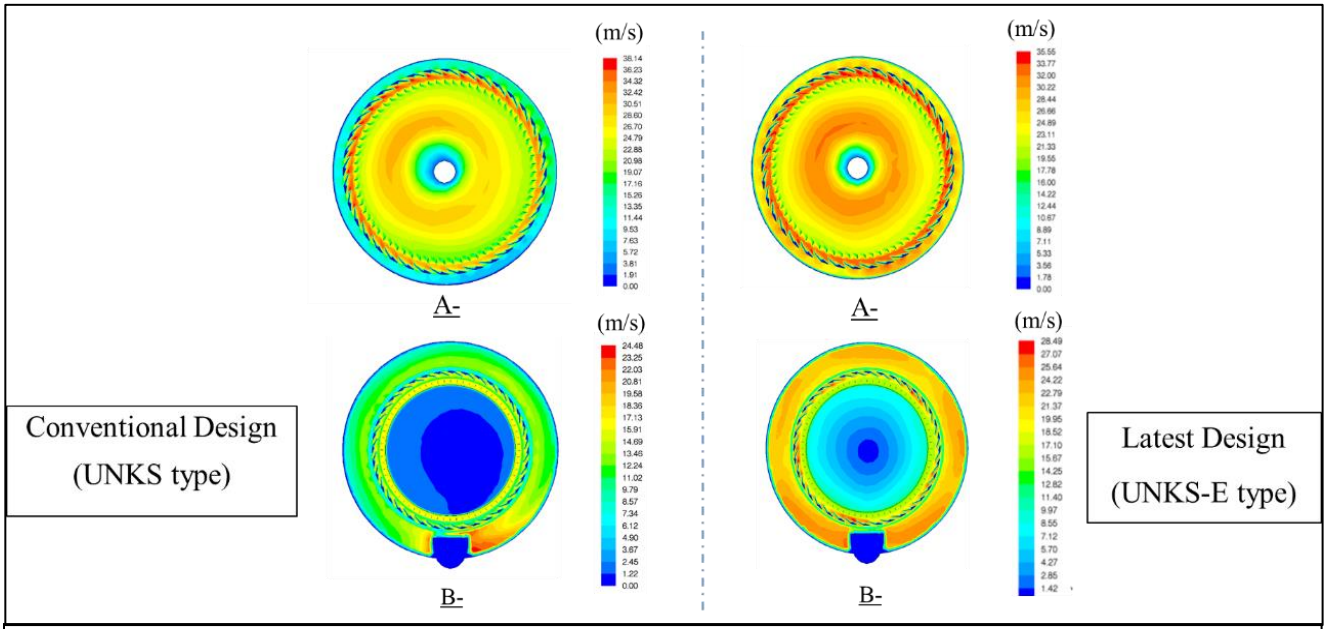


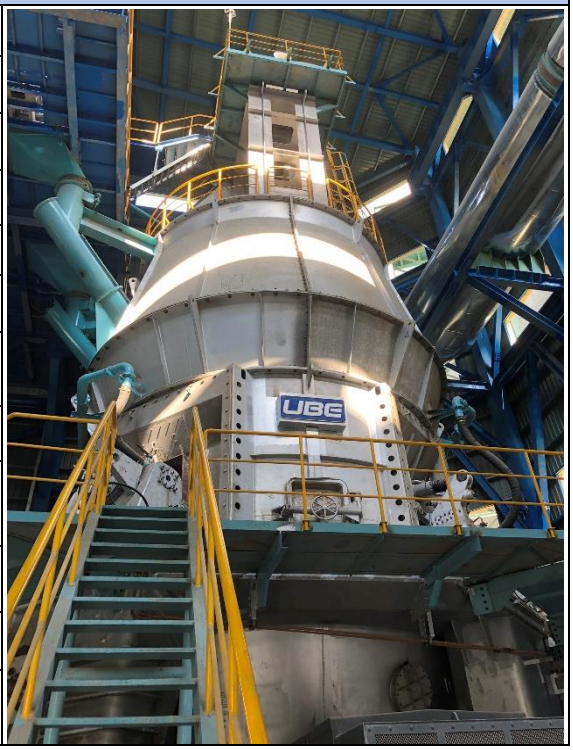
Figure 7. Comparison of Gas flow analysis result between Conventional and latest design.

Case Study at Chinfon Cement, Vietnam

As a case study of a clinker grinding VRM equipped with previously mentioned 2-Way System and the latest separator, UBE introduces the data from the No.5 Clinker Mill at Chinfon Cement in Vietnam, which was commissioned earlier this year (*Table 1*). In Chinfon Cement's plant, UBE installed two units of UBE's clinker grinding VRMs (No.3 and No.4 VRMs) in 2008. The comparison of the performance data for PCB40 cement grinding for the No.4 VRM and that of No.5 VRM installed this time are indicated in *Table 2*. Incidentally, the No.4 VRM is also equipped with the 2-Way System and the main difference between the No.5 VRM is the construction of the separator.

Table 1. Chinfon Cement / No.5 Cement Mill Details

Mill model		-	UM46.4CR
Number of rollers		-	2(Main)+2(Sub)
Table diameter		mm	4,600
Installed power of mill		kW	3,000
Separator model		-	UNKS75E
Installed power of separator		kW	250
Guaranteed (OPC grinding)	Capacity	t/h	120
	Blaine	cm^2/g	3,600
	P.C. (Mill + Sep + Aux.)	kWh/t	19.0
Achieved (OPC grinding)	Capacity	t/h	120
	Blaine	cm^2/g	3,671
	P.C. (Mill + Sep + Aux.)	kWh/t	18.8



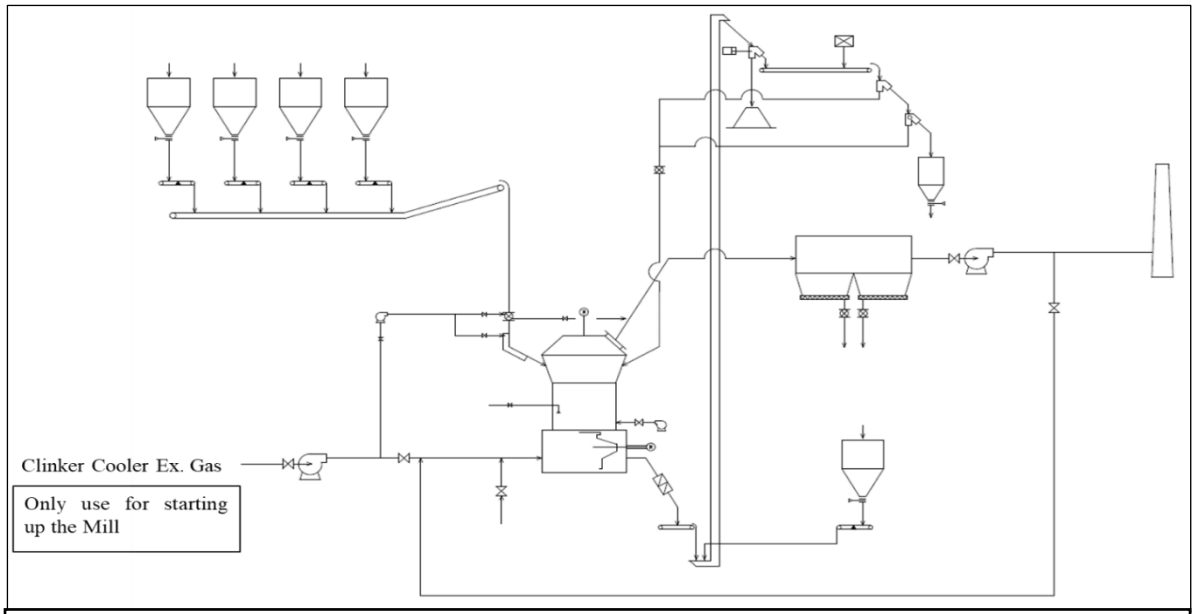


Fig 8.: Flow Sheet of Cement Mill at Chinfon Cement, Vietnam

As indicated in *Table 2*, although the product fineness (Blaine) for both No.4 and No.5 VRMs were similar, the cement produced by the No.5 VRM equipped with a new separator had lower 45μm Residue. Furthermore, an improvement in specific power consumption figure was witnessed. These tendencies were originally confirmed by the grinding test using the test mill at UBE's test laboratory and it can be conjectured that these effects were due to the velocity of gas flowing out from the separator becoming even by the decentered duct. Hence, by adjoining a new separator to the conventional 2-Way System, improvements in the quality of the ground product and energy efficiency were realized. Note that, due to the current production circumstances, both No.4 and No.5 are operating at the same capacity (145t/h); however, UBE is planning on investigating whether further increase in the production rate can be achieved in the near future.

Table 2. Comparison of Performance for PCB40 Cement Grinding

Mill			#4 Mill	#5 Mill
Mill model			UM46.4CN	UM46.4CR
Separator model			UNKS75 ***(Conventional design)***	UNKS75E ***(Latest design)***
Composition	Clinker	%	70.3	←
	Gypsum	%	3.7	←
	Limestone	%	5.0	←
	Black stone	%	9.0	←
	Slag	%	12.0	←
	Total	%	100	←
Capacity		t/h	145	145
Product fineness	Blaine	cm^2/g	4,048	4,028
	45μm Residue	%	10.0	8.7
Mill vibration		μm	30	25
Power consumption (Mill+Sep+Fan)		kWh/t	25.9	23.5

Conclusion

UBE and AMCL have signed an exclusive license agreement for manufacturing, sales, and after sales service of VRMs in India, Bangladesh, Nepal and Bhutan. This paper shared UBE's latest VRM technology (2 Way-system and Latest design separator) on energy efficiency. UBE and AMCL would provide Indian Industry with energy efficient technology in an efficient manner where due importance will be given to after sales services and overall customer satisfaction.

Acknowledgment

UBE gratefully acknowledges the provision of support by Chinfon Cement Corporation during the commissioning of the UM46.4CR mill. The data from Chinfon Cement is published in this paper with the kind permission of Chinfon Cement management.