A 600 TPD MD-VSK designed and installed by the authors (at CEMTAC, Srinagar, India). CEMTAC is now undergoing a further expansion of 600 TPD.

PREAMBLE:

The VSK is often regarded as a poor cousin to the Rotary kiln but due to our innovations we believe the same is no longer TRUE... (Please see Quality of MD-VSK Clinker in Tables 1 & 2)

INNOVATION 1

We call our VSK-----The MD-VSK (THE MODERN DAY-VERTICAL SHAFT KILN)**.**

We understood that the primary limitation in a VSK is that fuel (which is a contained in the raw mix or the nodules) cannot be increased or decreased like we can easily do in a Rotary kiln.

Hence if the raw mix fed to the VSK has a higher LSF (*than the designed LSF*) the Kiln would have a harder burning raw meal & therefore require more fuel for complete burning. However as further fuel addition is not possible *this will result in poor heat & thus un-burnt clinker or simply Lime & Silica dust.*

Thus from experimentation/experience we learned that for good VSK Clinker we need to limit the variation of LSF to +/-2% of designed raw mix…

For optimum quality of MD-VSK Clinker

- ✓ We recommend locating the MD-VSK where there is limestone (LS) having a CaO content greater than 48% *& the LS is of consistent quality*
- ✓ In case the LS quarry has LS of in-consistent quality, then we will need to install a Stacker and Re-Claimer AND Gamma-metrics (for online computerized correction in the feed to the raw mill). *This will of course increase costs…*
- ✓ Installation of weigh-feeders in the raw meal section working in tandem
- ✓ We have further improved on our raw mix blending systems for obtaining a homogenous raw mix

INNOVATION 2

We further understood that during Clinker formation, if the raw mix design is good, the fire will spread by itself (provided the air flow is not obstructed/LSF is within +/-2% range) as the formation of C3S is exothermic, *or evolves heat (100kcal/kg) which is similar to the normal burning of coal.*

Therefore we should not disturb the Clinker bed (like most remaining VSK operators worldwide are presently doing with their poking rods). *The heat will spread by itself in the direction of the airflow.*

In hindsight this is the same as the **Operating principle of a Rotary kiln** viz

- ✓ Attain the Clinkerization temperatures
- ✓ Leave the Clinker bed alone till it is discharged. (In the Rotary Kiln there is a tumbling action and therefore no obstruction in air flow.)
- ✓ However like VSK's the Rotary kiln too has many issues and requires careful monitoring

Thus, we modified our MD-VSK Design & Operating procedures.

INNOVATION 3

MD-VSK Design

- ✓ The Kiln operators can keep track of the fire/heat profile by thermocouples connected to an LED Screen
- ✓ In case the fire is low on one side (because the airflow is obstructed by some **Cold Clinker Lumps** at the bottom of the MD-VSK) then we can open the air from the pipes located near the top of the kiln. (See Fig 1: Design of the MD-VSK.)
- ✓ To avoid Cold Clinker Lumps the kiln has to be kept in a good running condition. Hence *the design of the cement plant has to be sturdy with least possible breakdowns and in practice attain a daily running average of 20 hrs*

- ✓ The Nodulizer is now fully automatic & nodule quality good for Clinker formation. This is due to the less formation of dust (which obstructs the air flow in a normal VSK) and the uniform size/porosity of the nodules.)
- ✓ The slope of the MD-VSK has been altered so that when the *Raw Mix Volume is reduced (with the formation of Clinker) the same is achieved without disturbing the clinker bed*
- ✓ The design of the Grate too has been modified for smooth extraction of clinker
- ✓ Lower pollution (see step 4)

INNOVATION 4

Operating procedure of a MD-VSK Kiln

The GOLDEN rule is
"NEVER FEED RAW NODULES DIRECTLY ON THE FIRE WITH THE BLOWER RUNNING"

If we do so we will have white balls in clinker as the coal burns away leaving behind CaO & Silica (Clinkerization temperatures of 1300-1450 Celsius cannot be reached. Limestone liberates Co2 at 900 Celsius).

Beginning of the shift:

1. At the start of the shift take a FIRE Ring Check (bringing the fire only up-to the outer circumference of the MD-VSK Shell. *The fire has the shape of O or the MD-VSK bed will GLOW to the shape of O.)*
2. To do the Ring Check, bring the level of the nodules to the bottom of the third brick. (The maximum Kiln level is the bottom of the first brick)
3. During the Ring Check, stop the grate and the feed. The fire should travel to the top *all along the MD-VSK circumference by itself in less than 15 minutes*, this indicates that the raw meal composition/Kiln is in a good running condition
4. If the fire comes up nicely, stop the blower, start the grate and the nodule feed and make a bed of raw nodules of 40-60 cm on the Clinker Bed. (The raw nodule bed has a further advantage of trapping dust in the air that would exit from the Chimney. The hot-air emanating from a Kiln consists primarily of water vapor)
5. Start the blower. Resume normal operations. Operating a MD-VSK is the co-ordination between blower, grate & feed
6. Our aim is to keep the ring of fire or the clinker bed at a level of 50-100 cm from the bottom of the first brick without stopping the grate, feed or the blower
7. If the fire keeps rising to the surface it means we can increase the feed
8. Seasoned operators can asses from the color of the fire and the smell of the gases, the condition of the kiln.
9. When the blower speed is at the maximum, the kiln is operating at Full Capacity.
10. If the burn-ability of raw mix is harder (higher LSF) then production will be lower. The laboratory has to find a balance between Clinker Quality & Production and the cement market requirements.
11. When the kiln is in a good running condition, the clinker discharge *will get hotter and hotter, till we can even have red hot clinker coming out.*
12. Cool the MD-VSK by stopping the feed and the grate, & running the blowers to bring the fire up. Request lab to decrease coal
13. Continuous red hot Clinker can damage the grate

14. Re-Start from step 4

Continuing from Step 3,

15. If the fire does not appear on all sides, continue the blower until the Kiln center and sides are fully burnt and the fire appears on all sides. Re-Start from step 4
16. *If the fire does not still appear on one of the side*s or the center, we should continue to do full poking. Poking means to burn all the contents in the kiln.
17. On the cool side, *we should make a clinker bed by using our sticks.*
18. Inform the laboratory and send the raw mix from the Nodilizer for analysis. The cause has to be analyzed as *MD-VSK's can run continuously for several weeks without resorting to poking*
19. In case there are big lumps seen after poking, only those above the Clinker Bed level (bottom of first brick) should be broken and moved to the center. Avoid touching the sides
20. If we disturb the Clinker sticking on the sides then the sides will be cool and till the MD-VSK reaches its running temperature we will have white nodules streaming between the Clinker bed & the cool sides as here the Clinkerization temperatures have not been achieved.
21. In normal course the formation/stickiness & the hardness of the lumps should be controlled by raw mix design. *This is determined by an empirical formula called the Liquid Phase*. The grate and Gravity will pull all the Lumps to be discharged easily in normal conditions
22. Re-start from step 4

General Instructions:

- ✓ No one should touch the Clinker Bed (Burning Zone)… the operators can use their sticks/rods only when there is a raw nodule layer. If the fire comes up and penetrates the nodule layer, it is better to stop the blower and increase feed and grate speed. Bring the bed down to 40-60 cm and restart from Step 4.

- ✓ NEVER FEED RAW NODULES DIRECTLY ON THE FIRE WITH THE BLOWER RUNNING.

- ✓ Use 1-1.5 cm diameter rods to check the position of the Heat Ring or the Clinker Bed below the circumference of the Kiln every 20 min.
- ✓ The Kiln should be checked for the ring every hour when Clinker is dusty and every 2 hrs when Clinker is good and the Kiln is in good running condition.
- ✓ Operating the Kiln is a skillful co-ordination between feeding the nodules, running the grate and the blower. The operators should try to understand the time of travel of the fire by one meter during the Ring Check to understand the burning characteristics of the raw mix and report to the lab.
- ✓ When the operators check the Kiln for the heat ring, then preferably the nodule bed should be brought down by 40-60 cm below the MD-VSK first brick level by operating the grate so that when we re-start the feeding the bed will return to a normal level.
- ✓ Be careful in lowering the MD-VSK clinker bed even for the Ring Check if the Clinker Bed is loose or disturbed. It is known that sometimes the fire can breach the grate.
- ✓ It is our aim to run the Kiln grate daily for at-least 20 hrs. We must install timers and take readings after every shift.

- ✓ If the lumps are hot, the air will pass through them so we do not need to worry about these. Only the lumps that have grown cold can disturb the air flow.
- ✓ Due to the disturbance in the air flow the sides of the Kiln may have differing levels of fire. On one side, the fire may be visible on the top & on the other side, 2 m below the top (The kiln can have a horizontal Fire Ring (ideal) or a Ring that is slanted (as maximum air will pass through the path of least resistance and fire will be higher where there is more air). Our aim is to keep this difference of level to a vertical height of less than 1-1.5 meters. This we can achieve starting from step 16

INNOVATION 5

Balancing Equipments of our MD-VSK plant

- ✓ We have incorporated *the latest technology in the design, procurement & manufacture of the balancing equipments*
- ✓ *MD-VSK balancing equipments are comparable to the state of art modern day Rotary plants*
- ✓ Our MD-VSK plants now have been designed to be **sturdy so as to run 330 days & to give 30+ years of trouble free working life**

INNOVATION 6

LOWER COSTS

We have cut down the costs wherever possible to the bare minimum without sacrificing Clinker & cement quality.

Example

In Venezuela, the promoters wanted a 3000 ton cement silo for a 600 TPD MD-VSK. We told them that 600 ton silo is more than enough in a location where there is cement scarcity as even 24 hr storage is sufficient.

- ✓ To give an idea of costs involved, the authors have signed a 5* 600 TPD MD-VSK turnkey contract in March 2014 for supply, Civil, Erection & Commissioning in Venezuela for ~10 million USD each (This does not include the cost of land, mines and the mining equipment so the installed costs of a million ton MD-VSK per annum plant (3000 TPD) with above exclusions will be 50 million USD or about a third the cost of a Rotary plant.
  (4*150 TPD MD-VSK plants will be established each in Portuguesa, Aragua, Yaracuy, Cojedes and Mérida)

- ✓ The commissioning time is ~18 months.

CONCLUSION:

Today the MD-VSK can compete with Modern day Rotary kilns in clinker quality as a younger brother and not a poor cousin.

Thanking you!

INNOVATORS of MD-VSK

1. **Er Sanjay Agarwal**

   He ran his own 65TPD MD-VSK from 1991-2002. Mr Agarwal studied several Chinese VSK installed at Qindao, China and has advised VSK plants in Latin America, Asia & Africa including the 180*2 TPD VSK of HOLCIM, Madagascar. He is now a freelance Cement consultant. He can be reached at sanjay143@gmail.com

2. **Praveen Sharma**

   He started his career with India's first VSK factory as Chief Chemist and now manufactures cement machinery under the brand name of Megatech International Pvt Ltd. His company is supplying to CEMTAC & Venezuela. He can be reached at mipl2003@gmail.com

Above: Signing of the 5*600 TPD Venezuelan contact. Starting from the extreme left are Mr. Sanjay Agarwal and Mr. Praveen Sharma.

Table: 1

We give below the actual working of a MD-VSK taken from a production sheet on 2 consecutive days: The raw meal fed into the kiln and the Clinker quality. As you can see the free lime is less than 2%

09-Dec							
RAW MEAL				CK MD-VSK 1		CK MD-VSK 2	
LSF	MS	MF	LOI	F-LIME	LSF	F-LIME	LSF
				2.89		1.64	
89.69	1.79	1.53	40.36	2.68		1.95	
				2.17	92.62	1.53	93.48
92.44	1.98	1.26	41.94	1.98		1.88	
				1.80	92.25	1.80	91.32
93.70	1.95	1.24	40.38	1.63		1.55	
				2.06	91.61	2.51	93.78
93.00	1.97	1.28	40.59	2.00		1.72	
				2.20	89.48	1.58	92.85
92.46	1.95	1.27	40.46	1.84			
				2.00	93.89	1.64	90.70
				1.66			
90.92	2.01	1.27	40.71	1.92			
91.69	1.96	1.23	41.19				
90.66	1.86	1.30	40.77	1.67	95.74		
PHASES MD-VSK 1							
	C3S	C2S	C3A	C4AF	FL (Liquid Phase)		
	46.51	25.63	8.52	14.30	30.51		
PHASES MD-VSK 2							
	C3S	C2S	C3A	C4AF	FL		
	46.99	25.30	8.73	14.28	30.74		

Table 2

10-Dec							
RAW MEAL				CK MD-VSK 1		CK MD-VSK 2	
LSF	MS	MF	LOI	F-LIME	LSF	F-LIME	LSF
92.98	1.95	1.29	40.57				
92.72	1.97	1.26	40.51	1.79		1.19	
91.85	1.95	1.27	40.91				
91.23	2.01	1.32	43.44	1.64	91.99	1.20	93.52
92.32	1.94	1.27	41.55				
91.76	1.94	1.27	42.29	2.04			
91.28	1.98	1.26	41.39				
91.75	1.96	1.26	40.53	1.20	90.28	1.35	92.97
91.11	1.96	1.29	39.40	1.68		1.62	
92.01	1.96	1.28	41.36	1.37		1.42	
91.75	1.97	1.25	41.50				
90.61	1.97	1.29	40.90	2.18	91.61	2.33	91.76
90.28	1.88	1.26	40.05				
93.68	1.98	1.25	40.30	2.00		2.18	
92.03	1.99	1.26	40.09				
91.85	1.92	1.24	41.19				
94.90	1.92	1.24	40.21				
PHASES MD-VSK 1							
	C3S	C2S	C3A	C4AF	FL		
	44.15	28.08	9.25	14.17	31.17		
PHASES MD-VSK 2							
	C3S	C2S	C3A	C4AF	FL		
	48.87	23.72	8.55	14.41	30.61		

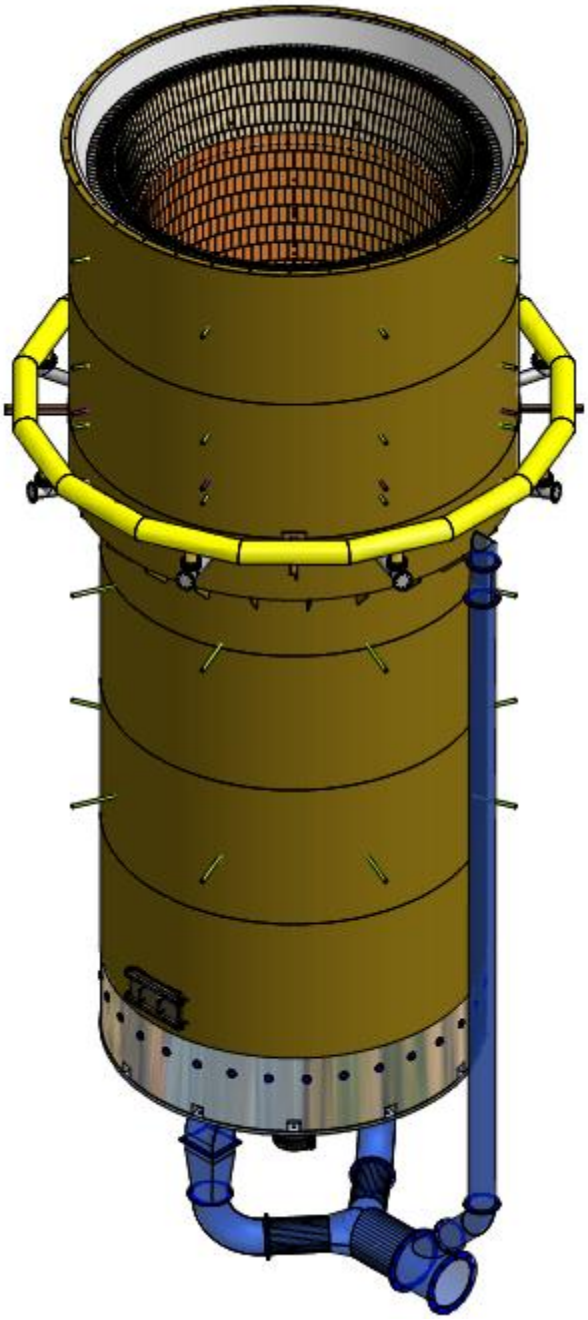

Fig 1: A MD-VSK Kiln: Note the air-pipes and the thermocouples