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VSK advances

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While vertical shaft kilns (VSKs) are often regarded as the poor cousin to the rotary kiln, recent advances in VSK technology and operation have gone some way to counteract its main limitations.

Sanjay Agarwal and Praveen Sharma (on the left) sign their latest VSK contract in Venezuela in March 2014

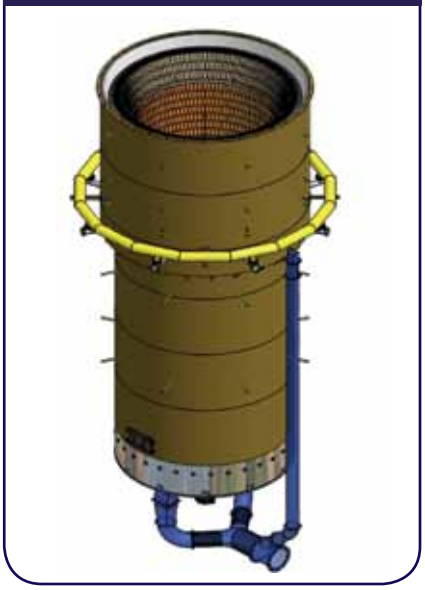
The latest developments in VSK technology have focussed on the optimisation of the raw mix lime saturation factor (LSF) versus the fuel share in the nodules and improving the kiln's heat distribution, leading to design modifications and changes in working practices.

India-based Megatech International P Ltd (MIPL) has incorporated the latest technology in the design, procurement and manufacture of its VSKs and its balancing equipment. As a result, the company's MD-VSKs are on a par with modern rotary kilns. Moreover, the equipment has been designed to run 330 days per year and offer over 30 years of trouble-free operation. MIPL has designed VSKs with a capacity range of 50-200tpd. In March this year, the company signed a contract to supply, erect and commission four 150tpd VSKs in Venezuela. Commissioning of the project is expected in 18 months' time.

Optimising the raw mix LSF

The primary limitation of a VSK is that fuel, which is contained in the raw mix or the nodules, cannot be increased or decreased, as is the case in a rotary kiln. This presents issues in situations where the raw mix fed to the VSK has a LSF that is higher than the designed LSF as the raw meal would be harder to burn and require more fuel for a complete burn. As fuel addition is not possible, the VSK will have a poor heat environment and, as a result, unburnt clinker or lime and silica dust will be present. Therefore, to obtain good-quality VSK clinker, LSF variations need to be limited to ±2 per cent of the designed raw mix.

Figure 1: MD-VSK kiln – air ducts help release air and improve air flow



In addition, VSK clinker quality can benefit from the following measures:

- locate the VSK where the limestone is of a consistent quality with a CaO content greater than 48 per cent.
- if the quarry has an inconsistent limestone quality, the plant would benefit from a stacker/reclaimer combination and an online analyser to enable computerised correction of the raw mill feed.
- install weighfeeders to work in tandem in the raw meal section.
- improve the raw mix blending system to obtain a homogenous raw mix.

Improving heat distribution

Following raw mix optimisation, further issues must be considered. During clinker formation, heat will distribute spontaneously in the direction of the airflow, provided the airflow is not obstructed and the LSF is within the ±2 per cent range, as the formation of C_3S is exothermic, evolving heat at a rate of 100kcal/kg, which is similar to the normal burning of coal. Therefore, it is important that the clinker bed is not disturbed, (eg, by operators using rods to move the clinker about).

MIPL's Modern-Day Vertical Shaft Kilns (MD-VSKs) have been designed and, when compared to traditional VSKs, modified to help obtain the required heat distribution. These design improvements include:

- kiln operators can keep track of the heat profile via thermocouples monitored via an LED screen
- if the airflow is obstructed by cold clinker nodules at the bottom of the MD-VSK (resulting in a low heat on one side), air can be released from the ducts near the top of the kiln (see Figure 1).
- 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 grate design has been modified to enable the smooth extraction of clinker
- the noduliser is now fully automatic and the nodules show a more uniform sizing and porosity. This improved nodule quality is due to the decreased dust formation,

(which reduces airflow obstructions).

Operating a VSK requires the optimum coordination between the blower, grate and feed. The ring of heat or the clinker bed must be kept at a level of 50-100cm from the bottom of the first brick without stopping the grate, feed or blower. If the heat keeps rising to the surface, then the feed can be increased.

The condition of the kiln can be assessed from the colour of the flames and the odours emitted by the kiln gases.

The kiln is operating at full capacity when the blower speed is at a maximum.

In addition, MIPL has modified the operating procedures of the VSK, keeping in mind the key rule to never feed raw nodules directly on the fire with the blower running. This avoids white balls in the clinker as the coal burns away, leaving behind CaO and silica.

As operational results in Table 1 show, these latest advances enable the MD-VSKs to compete with rotary kilns, producing high-quality clinker with an appropriate chemical signature.

Table 1: operational results from MD-VSK

Raw meal				*Clinker MD-VSK1*		*Clinker MD-VSK2*	
LSF	*Silica modulus*	*Alumina modulus*	*LOI @ 900˚C*	*Free lime*	*LSF*	*Free 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	*C_3S*	*C_2S*	*C_3A*	*C_4AF*	*FL*
MD-VSK1	44.15	28.08	9.25	14.17	31.17
MD-VSK2	48.87	23.72	8.55	14.41	30.61