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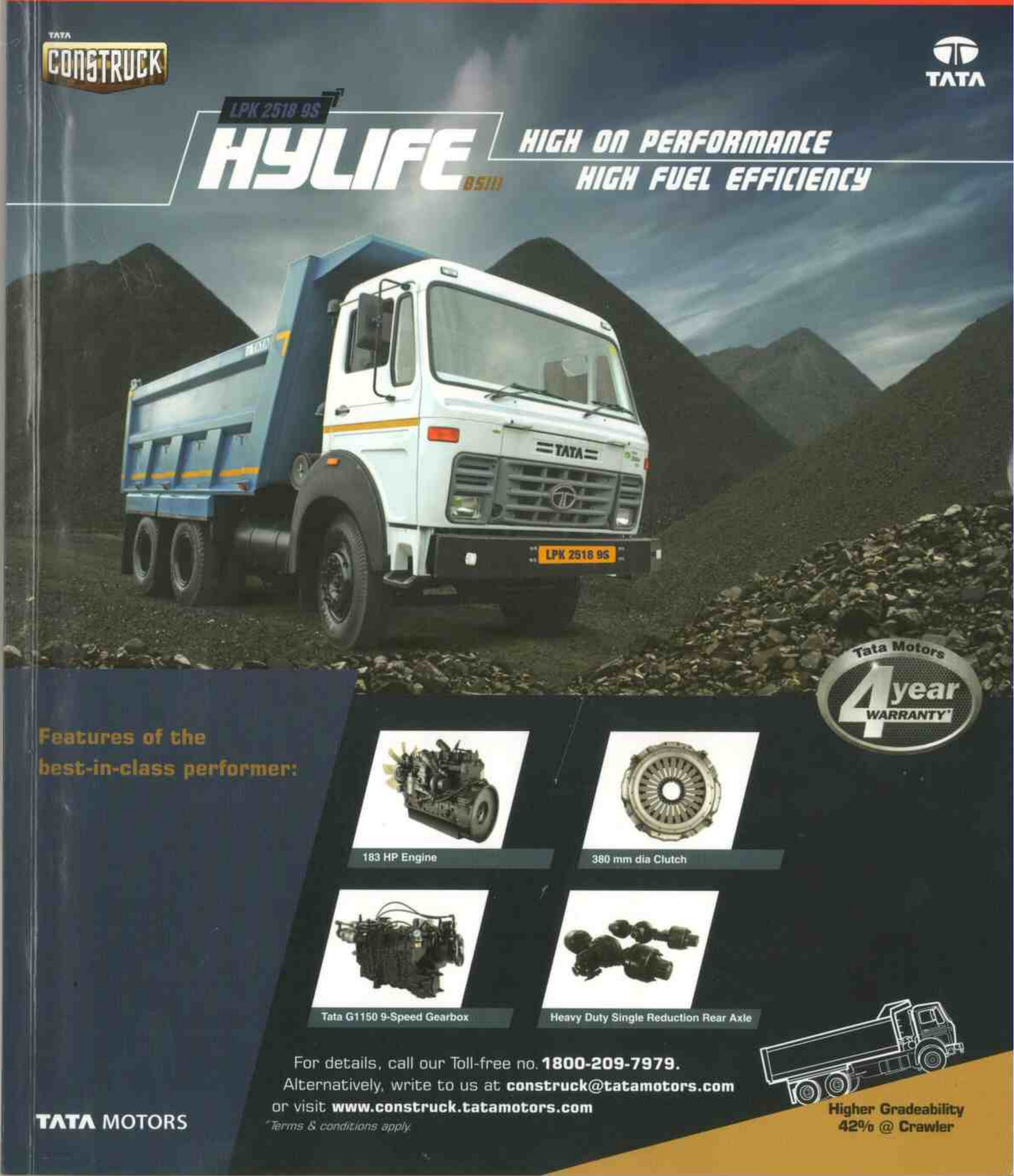
INDIAN CEMENT REVIEW

Winner of 4th CIDC-VISHWAKARMA AWARD 2012 for Best News Magazine

INDIA'S FIRST & ONLY BUSINESS MAGAZINE FOR INDIAN CEMENT INDUSTRY

VOLUME 27 • June 2013 • NO 11



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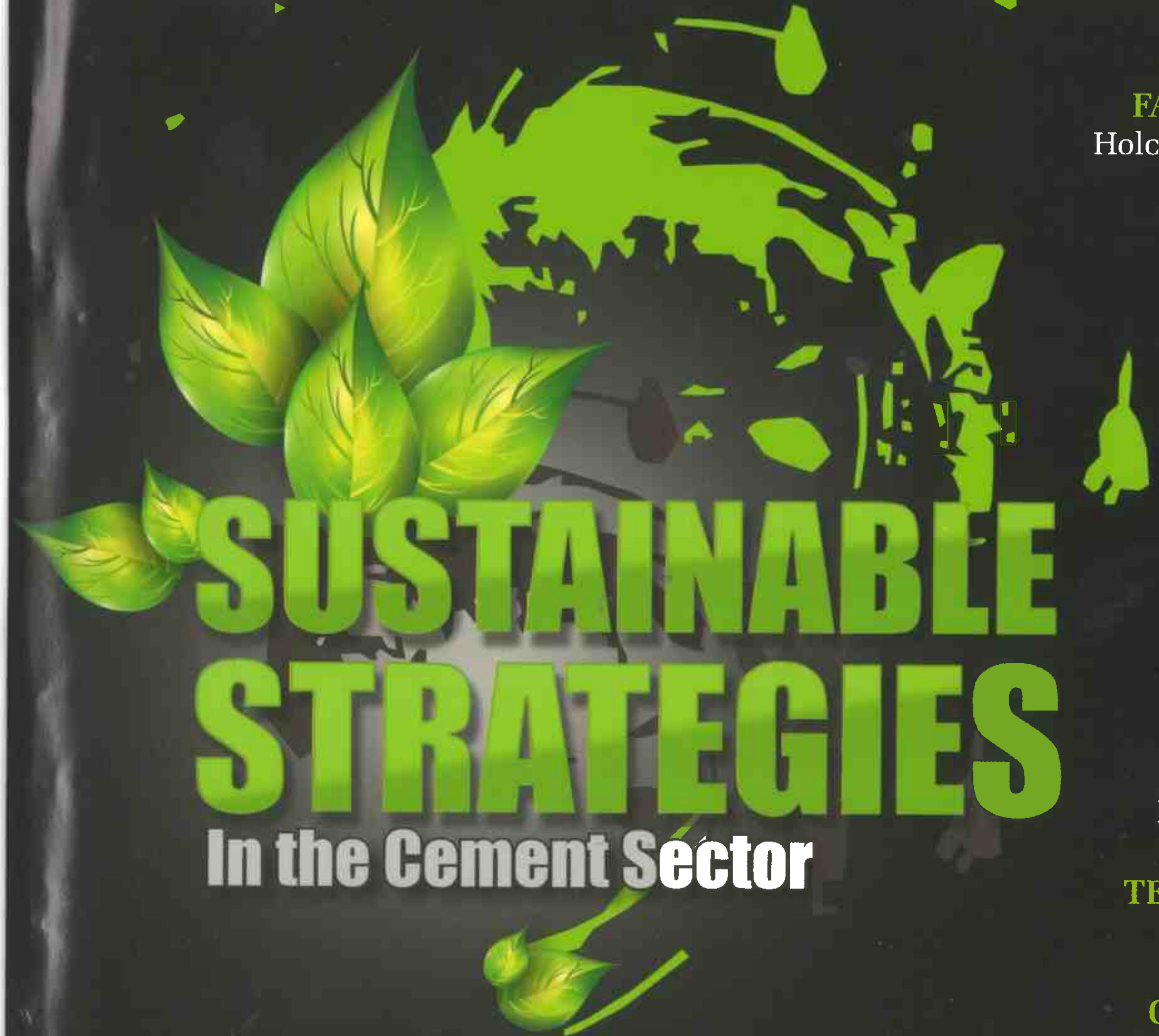

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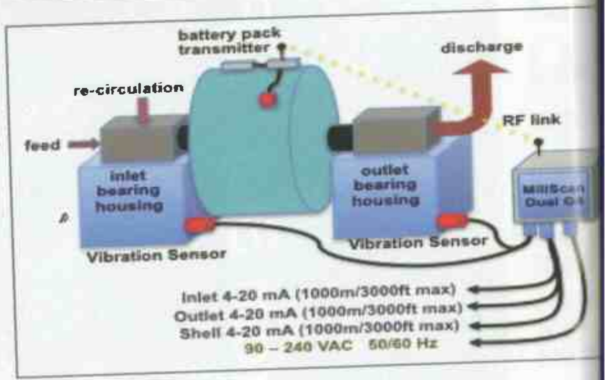
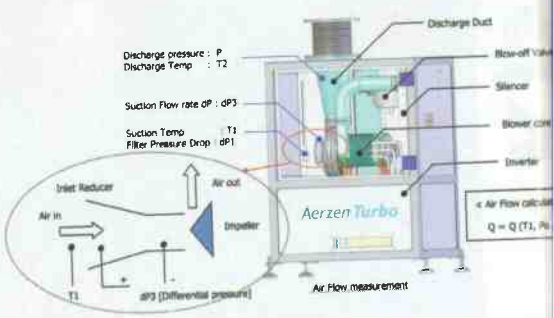


battery pack transmitter
discharge
re-circulation
RF link
feed
inlet bearing housing
outlet bearing housing
Vibration Sensor
Vibration Sensor
Inlet 4-20 mA (1000m/3000ft max)
Outlet 4-20 mA (1000m/3000ft max)
Shell 4-20 mA (1000m/3000ft max)
90 – 240 VAC 50/60 Hz



Discharge Duct
Discharge pressure : P
Discharge Temp : T2
Suction Flow rate dP : dP3
Suction Temp : T1
Filter Pressure Drop : dP1
Inlet Reducer
Air out
Air in
Impeller
Aerzen Turbo
Air Flow measurement

Mill Control Using MillScan G4

The authors presents an overview of mill vibration analysis and control and then illustrate an actual before and after case comparing mill control using classical techniques versus automate loop control using mill vibration to instantaneously estimate and control mill fill level.

HISTORICALLY many different signals have been employed in the quest for optimal automatic closed loop mill control. These include mill power, sound, elevator amps, bearing pressure and temperature as a few examples. However, within the last few years, a new technology is emerging that makes all these antiquated techniques obsolete. This new technology is mill control using vibration sensors, analog to digital converters and digital signal processing (DSP) techniques. It will be shown that significant improvements in material throughput, reduced kilo-watt per tonne numbers, improved material quality can all be realised with vibration control.

Bearing housing vs shell -mounted vibe sensors

Presently there are two main ways of monitoring vibration on a ball mill. Taking measurements from the bearing housing or some other fixed position or obtaining vibration signals from the shell of the mill. The MillScan G4 can actually do both. See the block diagram of this system in Figure 1.

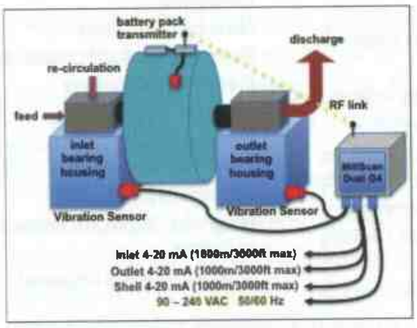


Figure 1. MillScan G4 Block Diagram.

Specifically we have found that the signal taken off of the inlet fixed bearing housing yields an excellent indication of the fill level in the inlet chamber or inlet half of a single chamber mill. Similarly, the outlet vibration signal can be used to tell what is going on in the outlet chamber or outlet half of the mill in the case of a single chamber mill. The signals obtained from these fixed locations are an integration of the grinding vibration occurring at a particular half of the mill. This means that we are using the metal support structure to sum all the vibration occurring in a particular half or chamber of the mill in the case where the mill has two chambers. Whereas we have found that the shell signal tends to represent a vertical slice of the fill level in the mill where the sensor is placed on the shell. Hence the least noisy and most stable signals are those taken off of the bearing housings. See Figure 2 as a comparison of bearing housing versus shell vibration.

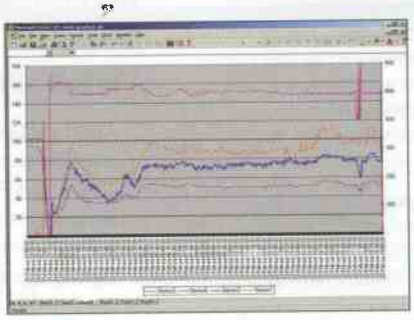


Figure 2. Shell versus Bearing Fill Level (Inlet).

In figure 2, the shell signal is in blue, the inlet bearing signal is in purple, the recirculation is in orange and feed is shown in pink. However, there are times when bearing vibration signals are not reliable and the shell sensor must be employed instead. This case occurs when the bearing oil pressure and/or oil temperature are not constant over daily hourly operation. Fluctuations in bearing oil temperature will cause the viscosity (thin-ness) of the oil to vary over time. This in turn will cause the acoustic coupling of the vibration taken off of the bearing housing to vary artificially. This problem should be fixed (i.e. oil pump or cooling fan replaced) but if not then the shell based sensor should be employed instead.

Fixed position sensors are able to detect changes to 1/10th of a per cent in fill level accuracy which then equate to +/- 0.01 mA on the 4-20 mA fill level output signal fed back to the control room. The shell based sensors are typically not as accurate but still far superior for mill control than a microphone based system.

Case study
JK Lakshmi Cements - Sirohi Cement Mill 2 and 5

Two mills with two compartments each were tested where each mill feeds to latest generation separators. This testing involved 2 mills and two separators. One mill gets normal feed size and another mill gets pre-ground material. The mill dimensions are Φ 4.6 X 16.0 meters long and Φ 3.8 X 13.0 meters long. The vibration control sensors were mounted on the feed trunions as shown earlier in this paper. The vibration signal was inserted into a PID in the same place where the mill sound level variable was used before.

Manual operation vs sound level vs vibration

Beginning with manual operation, this control scheme requires constant operator attention to attempt to optimize the variables associated with the mill. In this scenario, the moving loads in the mill and separators are left out of process control. These factors can be moving in different time intervals which make them hard to react to even with a good data historian and an operator's full attention.

This leads to conservative decisions with respect to feed tonnage in order to greatly ease mill operation. Basically the operator is afraid to push the mill anywhere near its true optimal operation. See Figure 3 as an example. Here a 100- kilowatt difference between the high and low mill power can be observed. With this shift in mill load we can expect more variation in the cement production than the case where the power consumption is more stable

Figure 3. Mill Power Result with Sound vs. Vibration (Y Axis = Ave. Kw. X Axis = hours).

Figure 4 is a comparison of the mill being controlled with a PID with mill sound versus vibration as the control variable. The theory of this control is that once the mill exceeds a maximum sound level it can be controlled automatically. Similarly if the mill sound is less the set point, the feed is decreased. Hence the control loop reacts directly to achieve the desired set point. One of the drawbacks of this operation is that it requires an operator to monitor the system until the sound level has been reached and then you switch to automatic control.

This is due to the fact that the mill must go through a power curve where it ramps up to a peak value initially as the mill fills from empty and then drops down as material causes the balls to move towards the chamber's center of mass line. Hence the optimal zone

Significant improvements can be realised with vibration control.

is on the right side of this curve. If you tried this optimal point in the control system at start-up, you won't pass this point and the mill will empty.

This control scheme also has a wide span of operating values for the sound variable. Typically the control system over and undershoots the target due to the slow response of the mill sound signal.

Unlike sound control, vibration control showed a much better ability to adjust to varying mill loading conditions. The system could also be placed in automatic control immediately upon mill start-up.

Figure 4. Mill Operation with Mill Sound vs. Vibration (Y Axis = Ave. Feed (TPH), X Axis = hours).

We found that the vibration signal reacts both to fresh feed and circulating load.

We also found that the smaller span and a faster signal response allowed the PID parameters to be shortened such that the control system made changes faster than in the kW/Sound level control case.

Results of running under vibration control

A comparison of results compiled from running for several months under vibration control versus mill sound control is now presented.

Beginning with kilowatts per tonne consumed, it was found that vibration control yielded an average Specific Power Consumption drop of 4.0 per cent and an average tonne per hour (TPH) increase of 3.5 to 4.0 per cent.

Other benefits

In addition to the improvement in mill power operation efficiency, it was also found that for two different products, the average standard deviation dropped by 15 per cent. The silo core strength test standard deviation dropped by over 30 per cent. This means that the produced cement was both closer to the desired target Blaine size and strength metric. This is a result of operating the mill in a more stable manner.

Conclusions

Fill level based upon mill vibration, is a fast repeatable precise signal. We have found it to be less noisy and more indicative of true mill fill level when it was taken off of the bearing housing than on the actual shell of the mill. This is due to the integration of total grinding energy observed at the bearing housing versus a point source measurement taken on the shell.

When using vibration for control, we have observed flat stable process signals such as mill, elevator and separator power.

This increased stability allows an operator to comfortably increase the throughput target for the mill while operating at a lower power point on the mill kW power curve. Hence we can produce more material for less power and thereby significantly decrease historical average kW hour per tonne numbers. Additional benefits are that as the mill becomes more consistent in operation (stable), improvements can be observed in -45 μ fraction and Blaine cement averages as well as improvements in standard deviations of these signals. Basically the more stable your process becomes, the more material for less power can be produced and with high quality levels. ■

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