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Process optimisation

by Narayana Jayaraman and Francisco Benavides, PEC Consulting Group LLC, USA

The emphasis on asset management in the cement industry usually focusses on maintenance and the related software used for scheduling and the systematic undertaking of necessary work to improve run factor and reliability. However, process optimisation should play an equally-important and complementary role in asset management.

Process-related inefficiencies are often the reason for poor production results. A good process optimisation programme significantly benefits asset productivity. These benefits include:

- lower energy consumption
- higher annual production rates
- steady operation resulting in less wear and tear
- consistent product quality.

The optimisation process applies to the entire production line starting at the quarry and finishing at the packing plant and dispatch. Since it is a continuous process, each section cannot be looked at individually as changes in one area will affect others.

Process optimisation attempts to identify applicable key performance indicators (KPIs) and benchmark them for the specific plant under study. This process involves comparing potential targets and adjusting for site operating conditions, raw materials, fuels, machinery and operating/control systems.

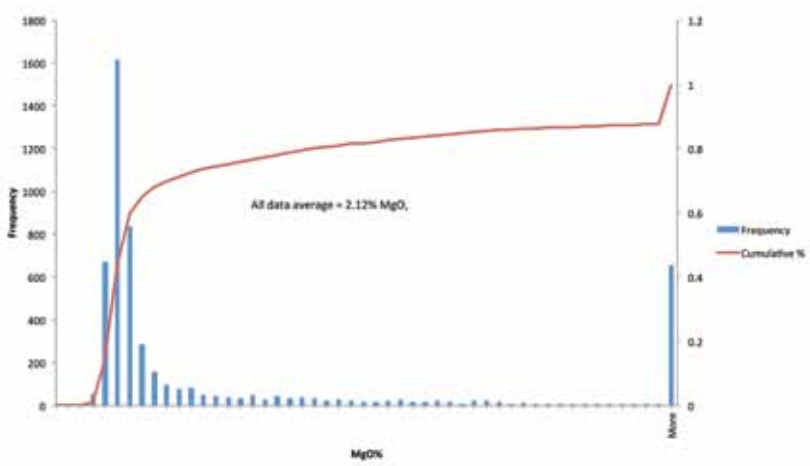
Quarry optimisation

The limestone deposit is the most important asset of a cement plant. Diligent use of the reserves increases the life of the mine. Limestone deposits are seldom uniform and vary in quality at different locations and different depths.

One of the most prevalent contaminants found in a limestone deposit is magnesium oxide (MgO) and therefore, its content in clinker needs to be carefully controlled. The quarry will have areas with very low MgO content and areas where the MgO level is high. In addition, other contaminants may be limited by regulations on stack emissions.

Good geological exploration and mapping of the deposits will help in guiding the mining operation to obtain the highest value of the asset. Optimisation of the mining plan will ensure that the quality is averaged right from the start and will extend the useful life of the deposit.

Figure 1: limestone quarry data – MgO content



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A process audit will help to:

- Review the limestone mapping and implement an optimum long-term mining plan for both mining economies and life of mine.
- Resist the tendency to use up the 'sweet' spots initially, making it difficult to manage the deposits in later years.
- Optimise mining logistics to minimise transportation costs.

Figure 1 is an example of a plant where the borehole analysis indicated a reserve average of 2.12 per cent MgO. If the plant chose to operate at an initial comfort level of <1.6 per cent MgO, nearly 25 per cent of the deposit would be unusable. However, careful averaging of the MgO content right from the start by implementing an optimised mining and blending programme increases the share of useful deposits.

Raw mix design

Raw mix design is a key aspect in process control. The raw mix typically has a CaO content of ≈ 45 per cent. If all other components occur in the right proportion, limestone with 45 per cent CaO would be sufficient. However, the plant needs to seek richer limestone to adjust for the chemistry of other raw meal components. The optimisation process covers the mix composition, assessing the chemistry of the available raw materials and adding, if necessary, other materials rich in specific components such as bauxite, silica or iron. This sets the target chemistry for the kiln feed and the proportions in which different components are to be blended. The control strategy to achieve the target chemistry and the level of

A process audit helps to streamline logistics and ensure better use of vehicles and mobile equipment in quarries and around the cement plant

homogenisation begins at the mining operation and ends when the material is extracted from the homogenising silo.

Optimisation of the raw mix is carried out by iteration, seeking to maximise the company's mineral resources and at the same time minimising operating costs.

Preblending stockpiles

A good stockpile-forming strategy is key to quality control. Even good design and well-maintained equipment cannot achieve the best raw material preparation if the stacking-reclaiming process is not optimised by the right operational strategy.

This is especially critical when a multi-component pile is planned due to a large number of raw material sources. The pile formation strategy must ensure each component is deposited over the full length of the pile and the mean of the targeted parameter (typically the lime saturation factor – LSF) for each 'slice' during reclamation is the same. The reclaiming process homogenises the pile blend so that the reclaimed material can be loaded into the main mill-feed bin as a single key component.

Additional corrective raw materials such as silica, alumina and iron are dosed as required into the mill feed stream from feed bins' weighfeeders. The raw mix planning should cover which materials need to be blended in the stockpile and which need to be added from the mill feed bins and weighfeeders. Lack of homogeneous quality in the chemistry fed to the mill is a major factor limiting the kiln's annual production. Ad-hoc measures to blend different components will lead to unstable kiln operation and low overall production.

Raw mill

Once the feed material enters the raw mill, there is no further correction possible as usually there is no provision to add any corrective component after this point. Exceptions are:

- coal ash absorption
- if there is a bypass arrangement or filter dust is wasted
- special direct feed arrangement into the kiln.

Even if the raw mill feed chemistry has a long-time mean as the target, the degree of homogeneity, represented as the standard deviation of the target parameter (LSF), is not adequate at this point for a stable kiln operation and will need to be improved in the homogenising silo.

The process optimisation reviews the raw material proportioning strategy and defines the sampling program to ensure that the chemistry mean is achieved in the shortest possible intervals. Optimisation further reviews factors such as the raw mill operation and the process control loop to ensure the desired fineness and drying.

From the raw mill on, the focus shifts to homogenising or reducing the standard deviation of the LSF value. The raw mill feed mean LSF value needs to reach the target generally within any interval of 3-4h of mill operation.

The strategy for achieving this lies with raw material proportioning control, typically performed with an online analyser located on the mill feed belt, which controls the weighfeeders on a continuous basis. In the absence of an online analyser, a good manual sampling and analysis programme needs to be developed.

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Homogenising silo

The function of the homogenising silo is to further reduce the Standard Deviation of the control parameter (LSF or CaO or $CaCO_3$ or C_3S) to prepare the kiln feed homogeneity to the desired level.

Depending on the control parameter, typically the standard deviation of the parameter is limited to:

- LSF < 1%
- CaO < 0.1%
- $CaCO_3$ < 0.25%
- C_3S < 3%

This is only a guideline and these parameters need to be studied for each process line to achieve the optimum limits based on raw materials, processing equipment, clinker quality desired and additives introduced at the cement mill. Analysis needs to be carried out by a specialised process engineer.

Assuming the homogenising silo is in good order, the strategy is to bring about proper mixing by choosing the appropriate sequence for opening extraction ports (see Figure 2).

Process optimisation includes reviewing and making adjustments, if necessary, to the filling and extraction programme, ensuring the silo level is above the required minimum as well as reviewing the recycling system of CKD from the baghouse.

Figure 2: FLSmidth CF silo

Pyroprocessing

The pyroprocessing system constitutes possibly the most central asset within the plant as it is usually the process that limits overall capacity and economics.

A process audit and optimisation helps to conserve this asset and get the most from it in terms of run time and production levels. An optimised operation prevents or minimises the potential issues outlined below.

Preheater plugging stoppages
Managed through:
- sulphur-alkali balance
- oxygen level in the burning zone
- bypass management.

Refractory damage
Due to properly-managed chemistry and combustion:
- burning zone temperature
- burner pipe positioning
- flame momentum and shape
- chemistry management.

Operational instability and the resulting quality variation managed through:
- better homogenisation
- constant degree of precalcination
- kiln filling/rpm management.

Under-utilisation of raw materials (eg, high free lime)
Managed through:
- optimum LSF
- burning control.

Higher heat consumption and higher operating costs
Managed through:
- arresting in-leakages
- raw mix control
- minimising start-stops.

Higher electrical energy consumption and operating costs
Managed through:
- mills: external circulation, grinding media
- fans: variable speed drives
- arresting in-leakages
- clinker cooler operations.

Emission controls
Managed through:
- SO_2 and NO_x management – chemistry, process
- particulates: process dust and nuisance dust management.

Risks from interruptions (eg, fire and explosions in coal mill):
Managed through:
- minimising operation-related start-stops.

Maintenance costs
Managed through:
- minimising process-related stoppages and trippings.

Additional benefits
In addition to ensuring an improved run time, process optimisation results in energy conservation and production maximisation, thus increasing the return-on-capital.

Process optimisation has the same end goal of getting maximum return from the assets by managing the raw materials, process, control loops and quality control.

Logistics

A process audit helps to streamline logistics and ensure better use of vehicles and mobile equipment by minimising wasteful runs, under-loading of vehicles and preventing the lack of truck availability when required. This is especially significant in optimising truck movement in the mines. The expanse of the operation, involvement of heavy and slowly-moving equipment and expensive transport operations make an optimisation study very worthwhile.

Portable crushers and overland conveyors are good alternative solutions to trucking. However, these options require special study.

Plant upgrades

A plant audit reveals any savings potential in energy costs. Energy savings, such as a high-efficiency preheater fan, can also result in upgrading capacity. Arresting the in-leakages, lowering the pressure drop across the preheater and lowering the cooler losses are possible areas of optimisation. This manner of raising production represents a low investment cost per tonne of increased production as it is achieved by an optimum operational strategy with minimal capital investment.

Automation

Upgrading the automation level ensures constant improvement on quality and productivity. Real-time measurements and corrections help add safety factors and margins.

Workforce morale

An efficient and accident-free operating plant is a matter of pride for the management and the workforce. It accounts for higher morale among the workforce, which has a cumulative effect on production and safety.

An optimised operation

Assets in a broad sense refer to everything that contributes to the production process: raw materials, equipment, energy, operational strategy in every process area and the workforce.

The maintenance programme and software mainly focus on ensuring continuous trouble-free running of the equipment and minimising downtime. These are essential measures without which the equipment availability drops and the risk of accidents increases.

Process optimisation has the same end goal of getting maximum return from the assets by managing the raw materials, process, control loops and quality control.

An optimised operation ensures equipment reliability and longer run times. It also brings to light areas in need of investment, which translates into significant returns and helps to prioritise future projects.