Plant Optimisation by Process Information Management

Mark Mutter – Cement Performance International

Introduction

The size of cement plants of recent years has continued to become larger and larger – both in terms of the overall capacity of the site as well as the design capacity of the individual pieces of equipment. Much of this drive (by both the cement producers and the equipment suppliers) is to attempt to maximse the efficiencies of scale in terms of fuel and power consumption, as well as reducing maintenance cost and number of employees. Ball mills for raw grinding have almost completely been replaced by vertical spindle mills (VSMs) on new plants, and the grinding capacity of VSMs has steadily been increasing over recent years. On existing plants cement producers have taken advantage of roll-presses to increase capacity as well as reducing power consumption of the ball milling systems. In the area of pyro-processing, plants have moved from single to twin string lines and with larger calciner vessels, the clinker capacity of single kilns has been pushed to over 12,000 tonnes per day. Advances in cooler design technology have allowed for much larger coolers with higher efficiency and lower maintenance cost to become the norm. Finally, the user of VSMs for cement grinding is becoming more commonplace in new plants.

Whilst the much larger size plants can deliver the benefits of scale, it is critical that these large plants are run at their optimal level. If they are not, the scale of the losses in tonnage alone is significant – for example a 1000 tpd kiln running 5% below target will lose 50 tonnes per day, whereas a 10,000 tpd plant running at 5% below target will lose 500 tonnes per day. This underperformance on an annual basis on the 10,000 tpd plant is 165,000 tonnes of clinker. Under these conditions or worse, the benefits of the economies of scale start to be lost and it becomes more difficult to achieve the desired return on the significant investment of the high capacity plant.

Within this paper some advice and recommendations are provided which should assist cement manufacturers in using all of the available data and information from the plant to ensure that they plant can be run under optimal conditions.

Process Information – The basics

Gone are the days when the only information from the plant was written down manually by the operators in the control room on log sheets. These sheets were generally taken away at the end of the month, stored in the laboratory until there was a problem on the plant, at which point the Process Engineer or Technical Manager would then dust down the sheets and attempt to extract the data to try and identify what was causing the particular problem in the process. This process was often laborious, with data manually being entered into a spreadsheet or regression program, as well as being limited solely to the small number of parameters that were tracked on the log sheets.

Current process control and data capture systems allow the plant to capture, record and analyses every plant signal that has been installed on the plant. Therefore, cement producers should be developing process monitoring system to take advantage of the vast availability of information that is available to them. As a first step, there should be a basic plant monitoring system that tracks the performance of each part of the process such that any particular trends or patterns can be picked up rapidly by those responsible.

Generally this tracking should be with either the production department or the process engineering department, as both of these departments are close to the day to day operations of the plant. Furthermore it is generally the process engineering department that is responsible for the investigation of drops in performance and therefore the process engineering would seem to be the best department to manage and monitor the process information. This may be a change for some plants whereby in the past the laboratory was responsible for the storage and dissemination of the plant data; however this tended to be on a monthly basis, for the purpose of the monthly accounts. Having data on a monthly basis may be acceptable for this purpose but it is not acceptable to review such critical production data on this frequency, as the losses will have already been made and as previously mentioned, a small drop in performance on a large kiln will result in significant losses.

So as a starting point, the plant should bring together a tracking system that takes the data from the plant and tracks it against the specific targets for each area of operation. Major items such as unit tonnes per hour, fuel and power consumption to be tracked. In addition to this the laboratory data should be tied into this system, whether manually or automatically dependent upon whether the plant has an automated laboratory. Even if the laboratory is not automated it is not a difficult task to have the data download from laboratory analysers to the data capture system. The chemistry data is extremely important for two reasons; firstly, tracking the chemistry data gives the plant the opportunity to examine the short and long term trends in the variability and therefore provides the opportunity to identify and correct the causes of any variability that is present. Secondly, many of the plant underperformance issues are related to the chemistry and therefore it is essential to have this data available in the daily analysis.

The setting up of the basic plant log is the stepping stone to a more comprehensive management and optimisation tool, which will be described later in this paper. However, additional benefits that have not been covered above are:

- The results of the analysis can be fed back to the control room operators such that they are aware of the impact of their actions. Obviously this needs to be done in a sensitive manner such that it is not perceived to be a criticism but a method of coaching to produce better results in the workplace. A good example of this is where it is responsibility of the operators to change the feeds to the raw mill when they receive the analysis of the raw meal that is being produced. If incorrect or excessive actions are taken in changing the raw mix, the chemical targets will not be achieved and when the next change is made, the actions that need to be taken will be even more significant and it may be that the targets are never achieved.

- The performance of different shift teams over periods of time can be analysed, thereby identifying any weaknesses and requirements for training. Again, such an approach needs to be dealt with sensitively and should be taken over a long period.

- The data capture system can be used for troubleshooting when the plant is underperforming. When the plant is running at optimum conditions, a reference point is recorded within the system which will allow the process engineering team to compare operating parameters when the plant is running well and when the plant is not running well. This can be the starting point for the investigation to return the plant to optimal conditions.

Development of the data system

The process information system as described above is just the start of the using the plant data to ensure the maximum amount of clinker is produced at the lowest possible cost. The plant data system should then be developed to become the plant data system as a reference point as well as a performance tool to highlight when the plant is performance is satisfactory and unsatisfactory. One of the most effective tools that can be set up with such as system is a slowdown log, which works as follows:

The Key Plant Performance indicators are taken from the annual business plan and taken as the targets for the slowdown log. These targets can be "headline" targets for the slowdown log and therefore on a daily basis the actual plant performance can be compared to the target and the gap can be calculated – for example plan tonnes per hour compared to actual tonnes per hour. Obviously if the actual is less than the plan then the gap will be negative and if actual is higher than plan then the gap will be positive.

On a daily basis the process engineering team should review the performance of the previous day to identify the reason why there is either a positive or negative gap. It is important to ensure that the reasons for the positive gap are investigated as well as the negative gaps such the factors that result in "over-production" are also recognised. For example it might be the case that there is some low LSF or low silica ratio material which has resulted in an easier burning mix which has increased output, but that will cause quality problems when ground into cement if not blended with a better quality clinker.

Clearly there must be some limitations to the level of investigation that is done on a daily basis and rules can be set within the system to indicate when further investigation is required. For example, over or under performance that is within 2% of the target can be ignored unless it occurs for 4 consecutive days. It is also important that the process engineers do not allow the system to take over from their day to day tasks. Whilst the process engineers are the champions of the system, it should also be open and used by all management personnel – and particularly the production department – to monitor the performance of the plant.

As many of the data manipulation systems that are currently available interface with Excel to produce their results, the system can also be developed to replace the written plant log where the process operators document the significant events of the shift. As production shift teams are on site 24 hours per day whereas most of the production and process engineering staff are on weekdays only, valuable information and events can be missed if not properly logged by the shift personnel. By moving the shift log onto the same system as the plant data capture, the actual events of the shift can be more easily tied in with the data that is captured on the system. This can be particularly important for unplanned stops such that the kiln burner or shift manager can document the events of the stoppage. This information will aid in the understanding in the reason for the stop and is also invaluable if there is a route cause analysis for the stoppage.

In many cases the reasons for slowdowns can be explained by certain plant circumstances such as low raw meal stocks or events such as reduced kiln feed due to environmental reasons. However over a period of time it is possible to build a database containing the reasons for the slowdown, including both the frequency and duration of the slowdown. Pareto analysis – almost identical to that which is built up for reliability of equipment – can then be used to identify the main causes for underperformance and these causes should be investigated using root cause analysis, removing each bottleneck one at a time by implementing the solutions if the investigations.

Other applications that have been developed using real time data capture systems are environmental emissions predictions systems. This works by setting the up a calculation within the system to log the hourly emissions of species such as NOx, SO2 and dust over a 24 hour period. The emissions limit for each 24 hour period is fixed and therefore as the emissions for each hour are registered, the system can then predict what the maximum emissions can be for the remaining hours of the 24 hour period. Therefore if high emissions occur during the early part of the shift, the kiln operator can then take the necessary actions to ensure that the plant stays in compliance. This may be cutting back on feed, changing the fuels proportion or calling in the maintenance department to review the operation of the environmental protection equipment.

Experience has shown that once a system has been put in place, users appreciate the value of real time data and that systems such as this tend to grow with other departments such as engineering becoming more involved, setting up their own areas on the system to track specific parameters relating to their own key performance indicators.

Off-line Process Data

Clearly there is some data that is critical to plant performance that is not available through the on-line monitoring system as it needs to be physically measured on the plant. This data tends to once again fall under the remit of the process engineering department to collect and analyse. The specific test work includes mill testing such as media size and ball charge levels, axial tests, airflow measurements and in-leaking air assessments as well as separator efficiency assessments. For the pyro-processing section this will include a heat balance, cooler efficiency, preheater audit, calciner combustion efficiency and in-leaking air audits.

Again, there are a number of key issues that should be noted in relation to this process test-work which must be noted:

- Process testing is not a one off exercise and little will be learnt by testing the plant on a one off basis. For each process test there must be a set frequency at which the test-work must be completed – not so frequent that the work takes up too much time of the process engineer or that very little has changed, but likewise not so long that changes within the process are not tracked. As with the on-line information that is collected, the off-line testing serves the purpose of building up a record of what is happening inside the equipment. The process engineering team must also be reactive enough that of the on-line signals from a particular piece of plant indicate that there is a problem, then one of the first things to do is perform the process test-work.

- Optimisation of the plant following on from the process test-work will often result in a number of actions being implemented and not just a one off solution. Therefore with a mill audit, the solution may be to alter the ball charge as well as change airflows on the separator and adjust the set points of the control system. All of the results of the process test work must be tied in with the parameters that have been producing the evidence that is found during the test work.

- The results of the process test work must be disseminated to all of the relevant parties on the plant such that each individual department can take responsibility for their particular area. Again, taking the cement mill audit as an example, the media loading and ball size data needs to be passed to the production department such that the correct media can be ordered and the necessary grading of media takes place. The step on the liners and therefore the wear rate of the liners needs to be passed on to the maintenance department such that plans can be made for the annual repair and any replacement of liners be planned in.

- As with the on-line system, where it is essential to understand the over-performance of the plant, it is also essential to take plant measurements when the plant is running well. This is one of the most common mistakes from process engineering departs – the plant is running well so the pressure is deemed to be off, so no plant testing is undertaken. When the plant underperforms, there is a rust to perform plant testing but there is no data set to compare it to when the plant had been performing well and therefore no reference point.

By regular testing the plant personnel, through feedback from the process engineering department, can have a much better chance of controlling the process and keeping it as close to optimum performance as possible. In some cases there is nothing that can be done in the short term following on from the test work i.e. the remedial action that is required can only be taken at the plant major repair; however it may be possible to take actions on the control and operations side that can reduce the impact of the findings of the test work.

Conclusion

The purpose of this paper is to highlight some of the opportunities that are available to cement manufacturers to make the best use of the information that is available to them with the current process control and data capture system, as well as ensuring that the data that cannot be captured by the system is also measured. Regardless of the system that is installed, it is the use of this system by the personnel on the plant that will result in the value being delivered. The system should be used to assess performance and identify problems, and to involve as many of the plant personnel as possible. The system should also pull in all possible data such as the laboratory data to ensure that a full picture of the operation is available. Whilst the system will provide on-line, timely information the process engineering department must continue to perform the routine process engineering test work on the plant to fill in the gaps that the data system cannot capture.