Precision with point counting

Point counting is an important tool for quality assurance of cement clinker, providing statistical information on composition, and grain size and shape. Associated software can count the points and provide analysis to keep track of the changing proportions, sizes and accuracy, thus enabling accurate data collection and reliable results.

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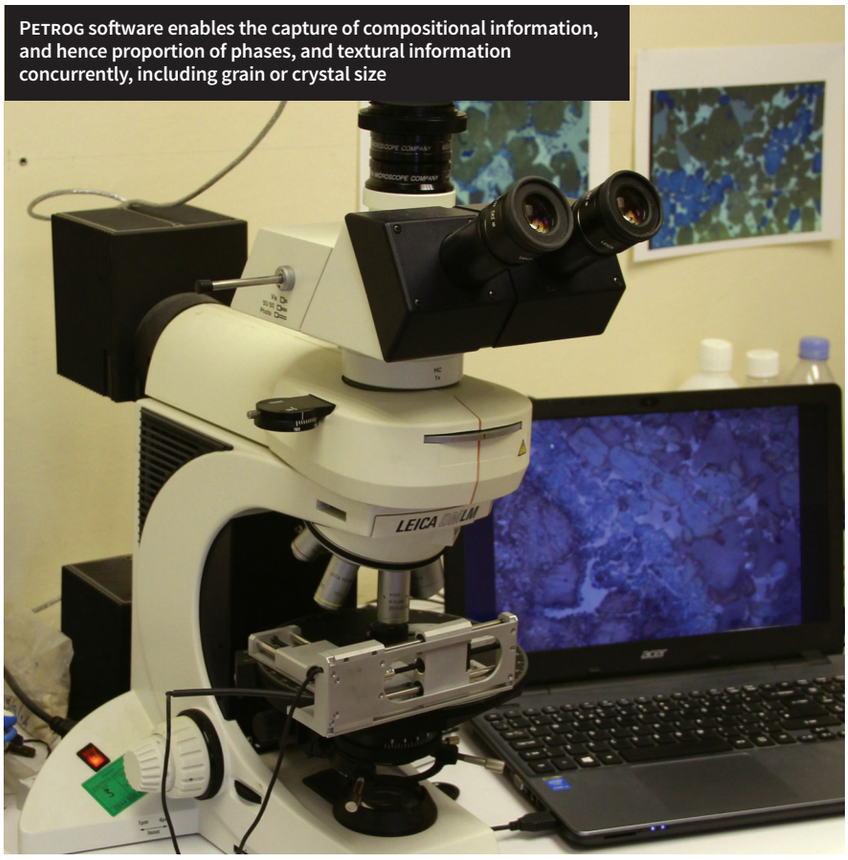
Microscopy is a well established technique for providing information on the quality of cement clinker.[1,2,3] Point counting is an integral part of this technique, providing statistical information on composition, and grain size and shape. An automated stepping stage greatly assists this task, providing a statistically valid selection of points to characterise. Associated software can count the points and provide statistical analysis. PETROG, conceived and developed by Conwy Valley Systems, is the leading software for petrographers, based on the only available fully-automated stepping stage.

Digital petrography benefits

Recently installed at Irish Cement Ltd, based in Drogheda, Republic of Ireland, following successful installations around the world, PETROG provides benefits including the capture of compositional information, and hence proportion of phases, and textural information concurrently, including grain or crystal size. This enables size histograms to be automatically drawn for each crystal type separately, as shown by Harrisson in a recent ICR article.[2]

ASTM C1356 (2007) gives guidance on the number of points to be counted for a given target accuracy, for either composition (proportion) or size. The results for accuracy of size estimates are all based on calculating the mean size from the measurements. It should be noted that the accuracy of other statistics, including standard deviation, skewness and multi-modality, and the accuracy with which the full size distribution can be estimated, is considerably lower. In general, to achieve the same confidence in the whole distribution, this would typically require an order of magnitude more points to be measured. As more points are needed, the quality of the tools used becomes increasingly important.

PETROG software enables the capture of compositional information, and hence proportion of phases, and textural information concurrently, including grain or crystal size

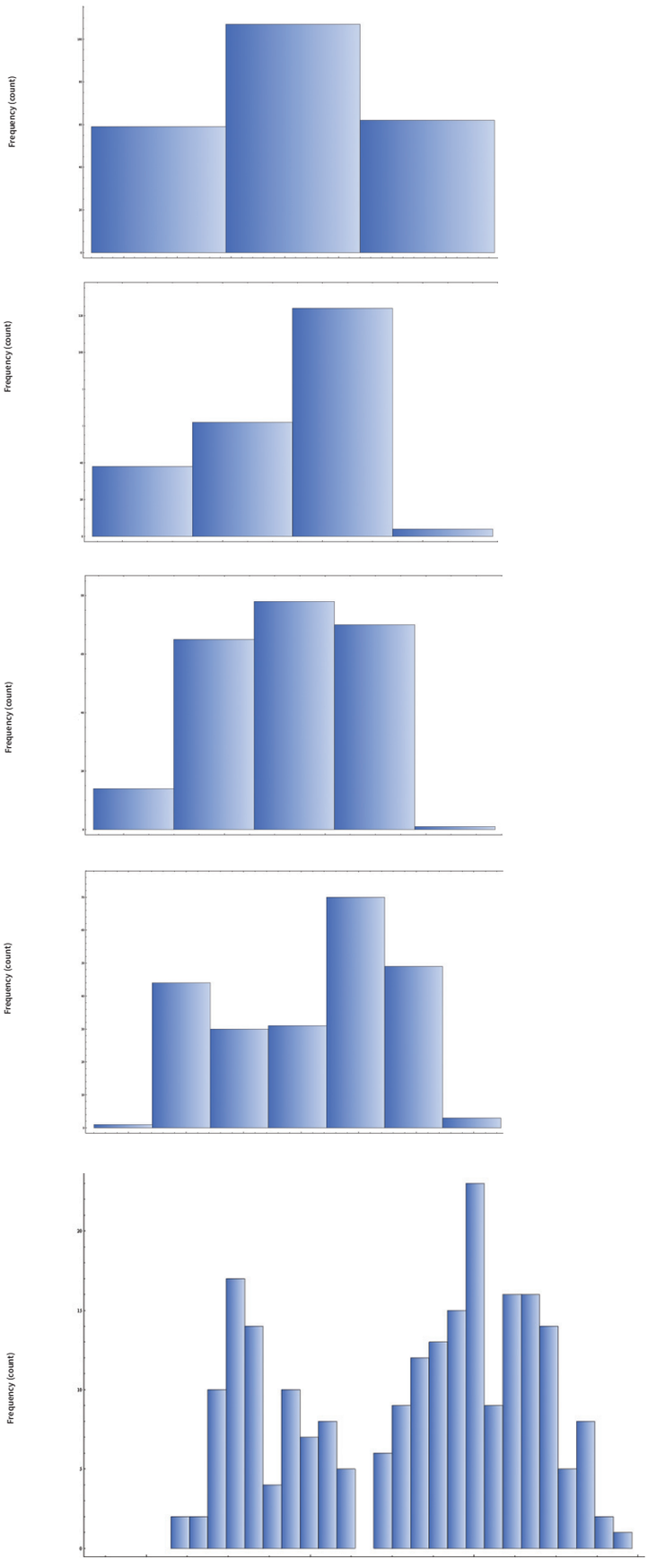


Having software that can keep track of the changing proportions, sizes and their accuracy becomes critical to efficient working, accurate data collection, and hence reliable results.

Dangers of insufficient investigation of data

The Wolfram demonstrations project (wolfram.com) shows a good example of the dangers of insufficiently investigating the data in histogram form (see Figure 1). It shows how the same data set (naturally occurring, not artificial or constructed specially to illustrate a point) appears to be symmetric, skewed or multi-modal, depending on how the histogram is drawn (in this case, only bin size has been changed, but altering the start point can also affect apparent distribution shape). What is rarely taken into account is how much confidence can be placed in an apparent shape: would the fifth depiction be a good indication of multi-modality or could it be just that the values (measurements) in the centre of the histogram, represented by empty or less-well filled bins, were randomly under-represented in the sampled subset? If the ASTM standard were followed, and the count continued only until there were enough points for the required confidence in the mean value to be reached, that would almost certainly not be enough to give us any confidence in multi-modality. It is commonly the case that the confidence

Figure 1: the Wolfram demonstrations project shows a good example of the dangers of insufficiently investigating the data in histogram form



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in the mean value passes the 95 per cent threshold whilst the confidence in higher moments (standard deviation, skewness, multi-modality) is still very low, not least because the calculation of confidence in the mean assumes no multi-modality (ie, assumes normality)[2]. So, if relying on the ASTM rule for confidence, we could be working with a predicted mean value that is not even seen in the data set.

Regular data collection and ready access

Data collected on a regular basis can be used for tracking changes,[1] and determining whether those changes are statistically significant. The original work on statistical significance of changes in a process over time was undertaken by William Gosset, who famously published his work anonymously, under the pseudonym 'Student'. His work involved comparing the quality of output from the Guinness brewery in Dublin on a daily basis, but part of his immense contribution to the then infant science of statistics was to realise that the same idea occurs equally in any process, including, some 115 years later, that at Drogheda some miles to the north. To use Student's t-test, it is necessary to have ready access to accurate information collected over long periods. Therefore, storing results in a database is important for the overall quality assurance regime.

This administrative task is thus as important as the technical task of data collection. In both respects, a tool such as PETROG is invaluable. ■

REFERENCES

[1] HARRISSON, AM (2018) 'Quantification of clinker microscopy' in: *ICR*, May, p59-64.

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[3] CAMPBELL, DH (1998) *Microscopical examination and interpretation of Portland cement and clinker.* Skokie, USA: Portland Cement Association, 48p.