

Percent Calcination

So just what is the meaning of the term, “percent calcination”? Good question and one that unfortunately we’ve incorrectly answered in our *Innovations in Portland Cement Manufacturing* book and CD-ROM and our *Cement Technical Support Library*. Ladd Parsons, an independent consultant known throughout the industry, caught our mistake and offered to help us set the record straight. So here we go...

Let’s start off with two samples; one from the kiln feed and one from somewhere further down the process stream. That second sample might be taken just past the calciner or anywhere else that we want to measure the percent calcination. Assuming a steady state environment, (no upsets, etc.), then the calculation should be pretty simple.

We know that the kiln feed sample starts off at 0% calcination. First, let’s calculate the weight of the kiln feed sample based upon a loss-on-ignition basis. That accounts for any moisture. Next, calculate the weight of a sample further down the process stream also based upon a loss-on-ignition basis. This will keep our weights on an “apples-to-apples” basis. If we then take that difference and divide by the original kiln feed sample (LOI basis), we should have our percent calcination. Right? **Wrong**. All we’ve really calculated is the weight loss in the sample.

INCORRECT FORMULA

$$\% \text{ calcination} = (f_{\text{kiln feed}} - d_{\text{sample}}) / f_{\text{kiln feed}} \times 100\%$$

The formula is incorrect because we’re assuming the difference in weight between the two samples is due entirely to the calcination process. That’s much too simplistic. Some of the weight loss is indeed due to calcination but there’s also weight loss in the sample from volatiles been driven off.

Ladd Parsons suggests that instead of using the **weights** of the kiln feed and sample; we use the **proportions** of volatiles to non-volatiles within the kiln feed and sample.

Let’s try it again using that approach. Same assumptions, but now calculate the ratio of the weight of kiln feed in volatiles per weight of kiln feed in non-volatiles. Next, calculate the weight of sample feed in volatiles per weight of sample feed in non-volatiles. If we subtract these two ratios and divide by our original weight of kiln feed in volatiles per weight of kiln feed in non-volatiles, we should actually have percent calcination. Right? Yes, because this time we’re accounting for the volatiles. The assumption that we’ve made is that the non-volatile weight of kiln feed and the non-volatile weight of sample are equal. If they are, then this formula truly does calculate the percentage of calcination.

CORRECT FORMULA

$$\% \text{ calcination} = [\text{LOI}_{\text{kf}} / (100 - \text{LOI}_{\text{kf}}) - \text{LOI}_{\text{sample}} / (100 - \text{LOI}_{\text{sample}})] / [\text{LOI}_{\text{kf}} / (100 - \text{LOI}_{\text{kf}})]$$

Still confused? Let's try an analogy that Bruce Shafer, California Portland Cement Company's Mojave Plant Manager uses.

Suppose that you have 65 pounds of bricks and 35 pounds of sponges. Burn the material until you only have 2 pounds of sponges left. There's still 65 pounds of brick that haven't burned. So the percentage "calcination" for this material, using our new formula, would be $(35/65 - 2/98) / (35/65) = 96.2\%$. That's the correct approach and correct answer.

If we would have used the Peray formula and the PCA formula, we would have calculated a calcination percentage of $(35-2)/35=94.3\%$. That is incorrect! Using the brick and sponge analogy, we've answered how many sponges were burned but didn't relate it back to the amount of bricks. The difference is especially crucial in new plant commissioning because the percentage of volatiles is an unknown and must be accounted for.

Ladd Parsons notes that using the incorrect formula not only understates the degree of calcination but might mislead operators into forming clinker earlier in the kiln system. That might be a cause of large alite crystals from a burning zone that's just too long.

PCA appreciates Ladd Parsons pointing out this error and we also want to thank Bruce Shafer for his easy-to-understand analogy. Thanks also to Greg Miller and Mike Singleton for their comments. By the way, this formula was used by all the Fuller commissioning engineers on the advice of Ishikawahjima-Harima Heavy Industries personnel when Fuller became the licensee for the IHI Flash Furnace system for precalcination application in cement clinker manufacture. Fuller was the predecessor of FLSmidth, Inc.

We hope that you'll use the *Innovations in Portland Cement Manufacturing* book and CD-ROM and let us know if you come across another mistake.