Stringent sampling

Philippe Davin* looks at how to collect a representative sample

"I have to analyse 200 g of product but I have a boat of 50,000 t of product. How do I proceed?" This question is a good starting point to explain and study what the sampling operation is or has to be. It shows how difficult it is to obtain representative samples in a process or from a large quantity of product and it also shows how essential the sampling operation is for product qualification (optimisation of the production, of the mine or for the quality classification of a product).

Is it possible to take a small sample (a few grams of product) for analysis with a simple bucket, diverter or bypass in the flow and obtain a result that is representative of the whole 'lot'?

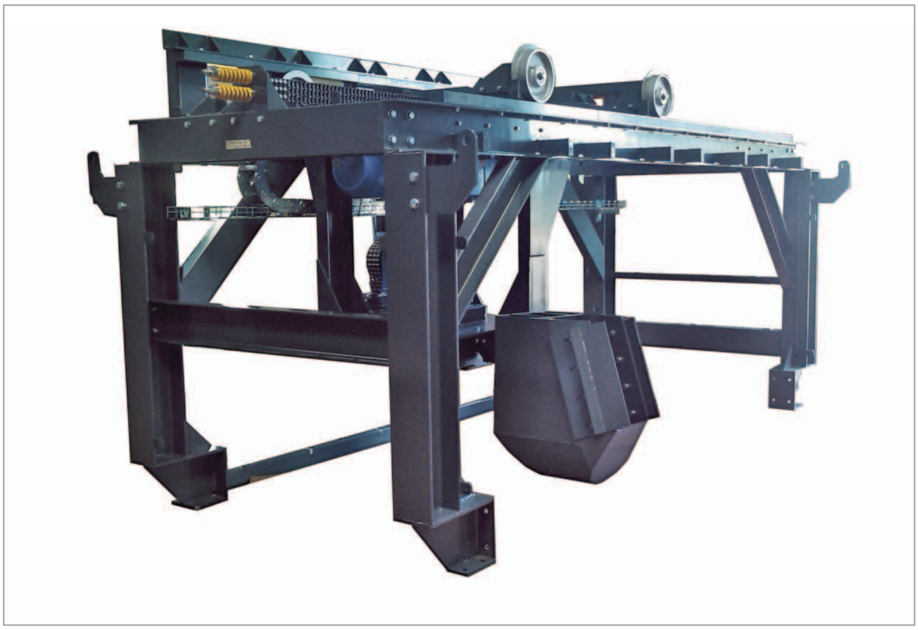
A 'lot' is the complete mass of product from which we want to obtain a representative sample. A 'lot' has to be considered for one analysis. For example, if we want one analysis for a whole 50,000 t boat, the 'lot' is 50,000 t. If two analyses are required for the same boat, the 'lot' would be 25,000 t. In a continuous process, if the flow is 2,000 t/h and we want one analysis per hour, the 'lot' is 2,000 t. If one analysis is required every eight hours, the 'lot' would be 16,000 t.

What could be the representativeness of 200 g of product, collected by a simple bucket, compared to 16,000 t? We have to remember how significant the results of the analysis based on a small 200 g sample can be. In the case of a boat discharging, the analysis on the sample gives information about the conformity of the product. The consequences on sales can be serious! In a continuous process, they can give information for the optimisation of a mine, for the quality of product or for the process control.

The main problem is the huge disproportion between the mass of the sample (200 g in our example) and the mass of the whole lot (50,000 t in our example). A few hundred grams of product have to represent several hundred or thousand tonnes. That is why it is important to understand 'homogeneity' and 'heterogeneity'.

Homogeneity and heterogeneity

A flow or a product is homogeneous when all the particles are strictly identical. Unfortunately, homogeneity cannot exist in the majority of solid bulk industries. That is why we have to consider the flow or the product as heterogeneous.



An example of a linear sampler at the belt's discharge point with bucket or spoon (according to application)

There are two types of heterogeneity though, the 'heterogeneity of constitution' and the 'heterogeneity of distribution.' The heterogeneity of constitution depends on the composition of each particle. Each particle can be composed of several minerals. The more diverse the particles are, the higher the constitution heterogeneity will be.

The heterogeneity of distribution depends on the distribution of the particles in the lot. If the composition, particle size, or density between particles is highly varied, the distribution heterogeneity is equally high.

Heterogeneities can be accentuated by the particle size segregation from handling systems. The most important segregation can appear at the discharge of belt conveyors. When a product is handled by a belt conveyor, movement and vibrations create particle size segregation, thus fine particles are located close to the belt. In this case, a particle size classification is then created and the heterogeneity of distribution is very high.

If we consider the discharge of this belt conveyor (Figure 1), its speed transfers kinetic energy to each particle. The bigger the particle, the higher the kinetic energy. That is why the big particles are far away from the chute compared to the fines. On a belt conveyor and at its discharge, the heterogeneity of distribution is very high.

The aim of the sampling operation is to collect a small mass of product which represents the whole lot for several analyses like particle size distribution, chemical analyses, humidity, etc. Those analyses will qualify the whole 'lot' or give information on it and because of the heterogeneity of the product it is very difficult to obtain a sample with exactly the same characteristics of the whole lot. This is why two important rules have to be respected:

- The sample has to be composed of a minimum mass of product. In fact, the bigger the maximum particle size of the product is, the larger the sample must be. Conversely, if the maximum particle size of the product is very fine, the sample could be composed of a very small mass
- The sample must be equiprobable, meaning all the particles must have the same probability to be collected by the sampling device.

A stockpile is another example of heterogeneousness: big particles or spherical particles roll outside the pile and fines remain concentrated to the centre. Because of this heterogeneity of distribution, representative samples can be collected when the stockpile builds up (at the discharge of the belt conveyor for example) or when the stockpile is completely handled.

Consequently, there should be no sampling without complete handling of the whole lot.

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Obtaining a representative sample

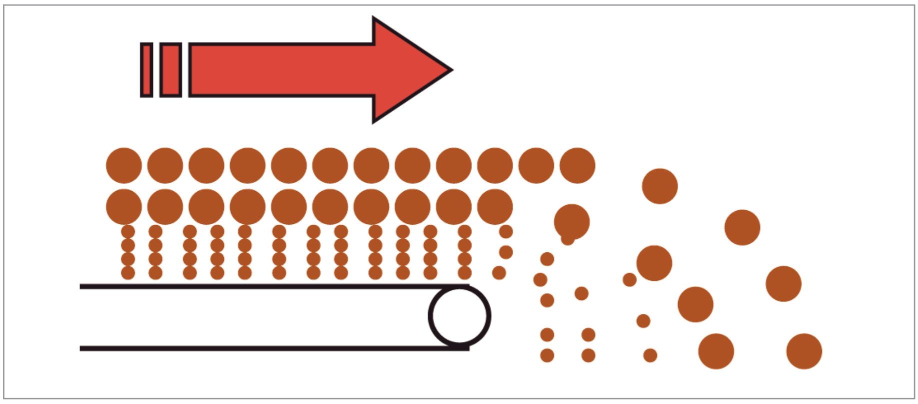
The sampling operation cannot be limited to a simple handling operation. Specific standards, sampling rules and theories have to be taken into consideration. That is why devices are divided into two categories: the 'sample-takers' and the 'samplers'.

A 'sample taker' is a technical device designed to take product. It cannot guarantee the representativeness and it collects 'specimens'. A 'sampler' is a technical solution designed to obtain representative 'samples'.

If we want to collect a representative sample, the first step is to obtain a **complete cross cut of the flow of material**. The second step is to **take into consideration the specific sampling standards** if they exist. The third step is to **respect theoretical knowledge** based on known sampling rules

Following these steps, samplers should be installed in chutes (discharge of belt conveyors or vertical ducts, etc.) because it is the best location for collecting a whole cross cut of the flow.

Accordingly, we have to be very careful about the cross-belt solution. This device cannot collect fine particles located close to the belt (otherwise the belt could be damaged) and owing to the heterogeneities and segregation, a bias could be obtained. This solution can be used in very few specific applications.



On a belt conveyor and at its discharge, the heterogeneity of distribution is very high

For many products, a sampling standard exists and explains how sampling operations should proceed: location of the sampler, type of sampling device, minimum mass of the elementary sample, minimum sampling frequency. They also give information about the design of the sampling device (width of sampling slot, sampling speed, etc.) These standards also teach how to reduce the mass of samples and then, help to design a complete sampling tower according to different analyses. Mineral producers and their customers use these standards to determine and verify the quality of the product according to the sales contract.

Sampling theories also present another way to design and calculate a suitable sampling solution. One of the renowned sampling specialists, Pierre GY, has written several books to explain his sampling theory which has become famous in the mining industry.

Pierre GY writes, "On primary sampling, bias can be up to 1,000% and up to 50% on the secondary sampling whereas they never exceed 0.1 to 1% in analysis."

The result of analysis depends on the quality of the sample. The more representative the sample is the more accurate and correct the analysis will be. But, we have to keep in mind that a non-representative sample can lead to false analyses and serious consequences. ***IM***