Automated Metering of Colour Pigments in Concrete Factories

Different possibilities of metering pigments in powder, compact, granule, or slurry form are described and possible advantages and disadvantages are pointed out.

The different methods have not been rated since, given the current level of automated pigment metering, the best method must be chosen on a case-by-case basis.

"Faster, farther, higher" is today's motto in the sports arena. But, the quest for new records is not confined to the recreational field. It also applies in the area of industrial production. Competition and the demand for better quality are forcing us to scrutinise manufacturing processes and to optimise them wherever possible. This is particularly true in the building materials industry.

The primary question here is how to optimise the concrete mixing process, stone manufacturing and logistics in the concrete factory.

To the manufacturer of coloured concrete products, efficient addition of the necessary pigments during the production process is also of critical importance.

This article gives an overview of the possibilities of automated metering of colour pigments in the concrete factory.

The Beginnings of Concrete Colouration

The practice of adding pigments to concrete products to make them more attractive started growing about 50 years ago. At that time, only powder pigments were available. At first, relatively small amounts of pigments were used by the manufacturers, and only a few colours were in demand. Manual addition of the pigments was generally considered adequate. Contamination of the workers and the production units where pigments were handled was considered the only drawback (see Fig. 1).

When the coloured concrete products met good acceptance in the market place, the pigment requirements of some plants increased drastically in some cases. Manual pigment metering turned into an increasingly expensive and time-consuming production step, so the industry began to look for possibilities of automating the process.

It very quickly became clear that volumetric addition via metering screw conveyors did not provide the required accuracy because of possible fluctuations in the bulk weight of the pigments. As a result, gravimetric metering – metering of the pigments by weight – prevailed.

Fig. 1: Contamination resulting from manual powder pigment metering

Metering of Powder Pigments

In an automated pigment metering process in a concrete factory, the question of where in the production process the pigment should be added is very important. There are normally three possibilities (see Fig. 2):

1. Addition on the aggregate conveyor belt
2. Addition to the bucket hoist
3. Direct addition to the concrete mixer

In any concrete plant, space is the main criterion in selecting the addition point. In many cases, there is not enough space on the mixer level so that a metering system cannot be installed close to the mixer. Since conveying the weighed pigment is extremely difficult due to the product characteristics, the addition of powder pigments directly to the concrete mixer will only be possible in the rarest of cases.

Instead, the weighed powder pigment is normally added to the aggregate before it is sent to the concrete mixer. In this case, the pigment is moved from the storage silo to the weighing scales by a screw conveyor and then falls either onto the aggregate conveyor or into the bucket hoist (see Fig. 3).

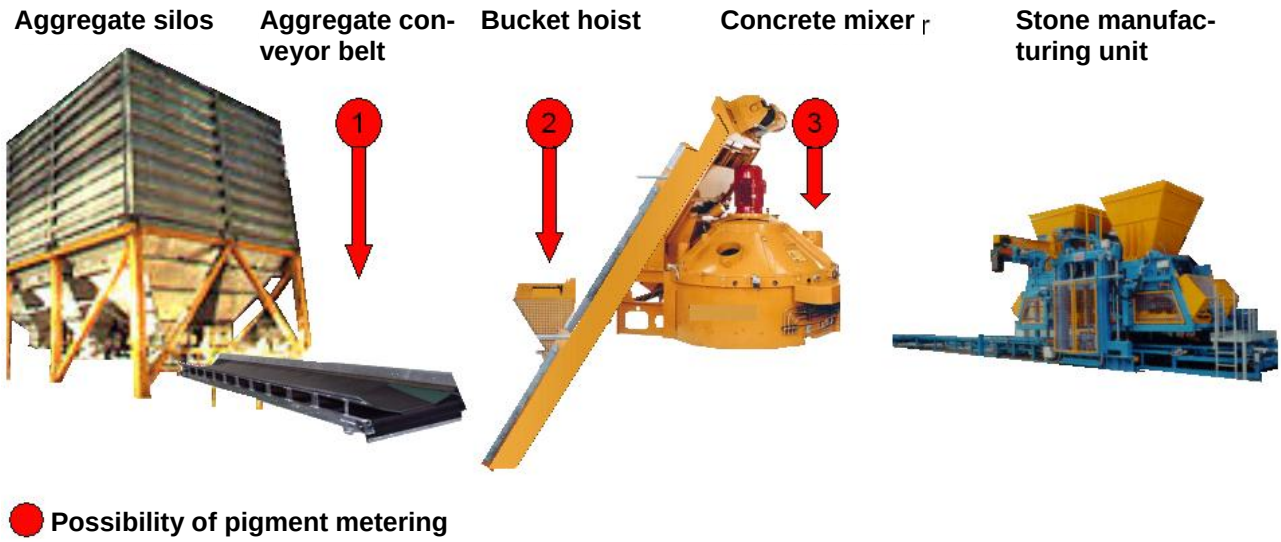

Fig. 2: Schematic of a Concrete Plant

With this mode of operation, solving the accompanying problems of severe dust development and poor pigment flow proves to be the main difficulty. The poor flow characteristics, in particular, mean that conveying powder pigments out of the storage silo and off the scales requires complex technical solutions. Deposits on the container walls are often unavoidable and may lead to metering errors.

Liquid Pigment Metering

The inorganic pigments normally used for colouring building materials can easily be made into aqueous suspensions. Such pigment suspensions – also known as slurries – flow freely, are free of dust, and can also be conveyed over longer distances with the appropriate pumps.

Liquid metering systems can therefore be installed at any suitable location in the concrete factory and still allow addition of the pigment directly to the mixer. This and the fact that the pigments can be added without contamination of the workplace quickly made liquid pigment metering very popular. A unit designed for the production of slurries at the concrete plant (on-site slurry) consists of one or more storage tanks. The storage tanks are equipped with agitators and serve to mix and store the slurries. Delivery is in most cases handled by compressed-air diaphragm pumps. The actual addition step takes place in a downstream metering cylinder or on liquid weighing scales.

However, there are also certain disadvantages. Manufacturing the suspensions entails additional costs, and the handling of powder pigments leads to contamination of workers and the workplace. Additionally, in a still suspension, the pigment tends to settle at the bottom of the storage tank relatively quickly. To solve this problem, the slurries are agitated at intervals and are continuously circulated through a ring line system (see Fig. 4).

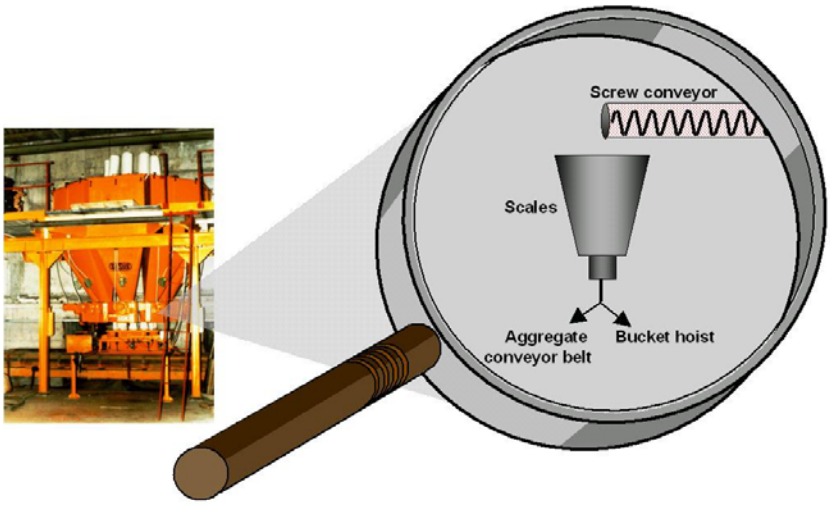

Fig. 3: Mechanical metering system: powder pigment metering

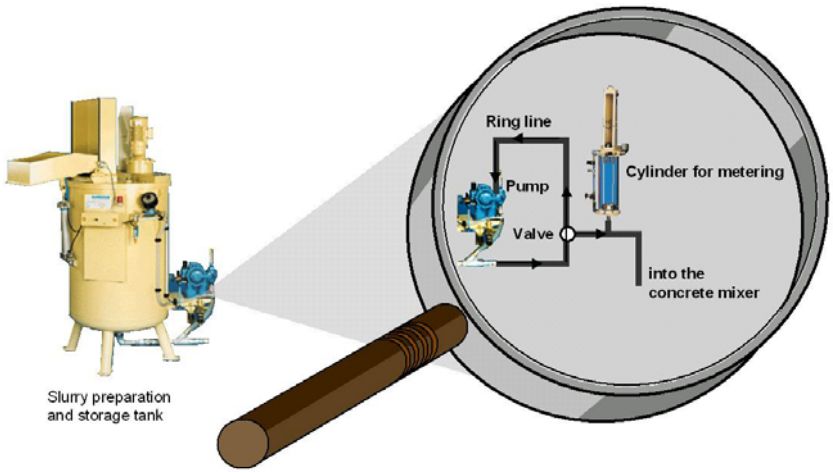

Fig. 4: Mechanical metering system: liquid pigment metering

Suspensions not produced on site but purchased ready-made from pigment suppliers have more favourable characteristics. These ready-made liquid pigments are stabilised by additives that lessen the settling tendencies. At the same time, the problem of contamination by pigment dust is also eliminated since there is no handling of dry pigments.

One fact to consider in this context is that the relatively high water content of the ready made suspensions impact the shipping costs. Also, additional freight costs may be involved since the product is normally delivered in returnable containers.

A general disadvantage of the use of suspensions is that along with the pigment more water is added to the concrete. When working with wet aggregates, this may make it difficult to maintain specified water/cement ratios.

Wet/Dry Metering

The perennial task of engineers is the search for solutions that combine the advantages of different systems and minimise the weak points of processes.

This also applies to the problem of wet/dry pigment metering. In this process, only the amount of pigment actually needed to colour the next batch of concrete is slurried.

To accomplish this, the amount of water required for preparation of each batch is added to a small agitated tank which also functions as a weighing scale. Subsequently, the appropriate amount of pigment is added to the agitated tank via a screw conveyor. The screw conveyor is controlled by the tank scales. After a short agitation period, the finished suspension can then be pumped into the concrete mixer (see Fig. 5).

The remainder of the concrete mixing water (for final adjustment of the water/cement ratio) is sent through the agitated tank. This ensures that no pigment remains in the tank and in the lines.

Wet/dry metering also allows the system to be installed at any suitable location in the plant for pigment addition directly to the mixer. Unlike liquid metering, wet/dry metering has no sedimentation problem since the pigment is stored in dry form. However, the problem of bringing additional amounts of water into the cement along with the pigment remains.

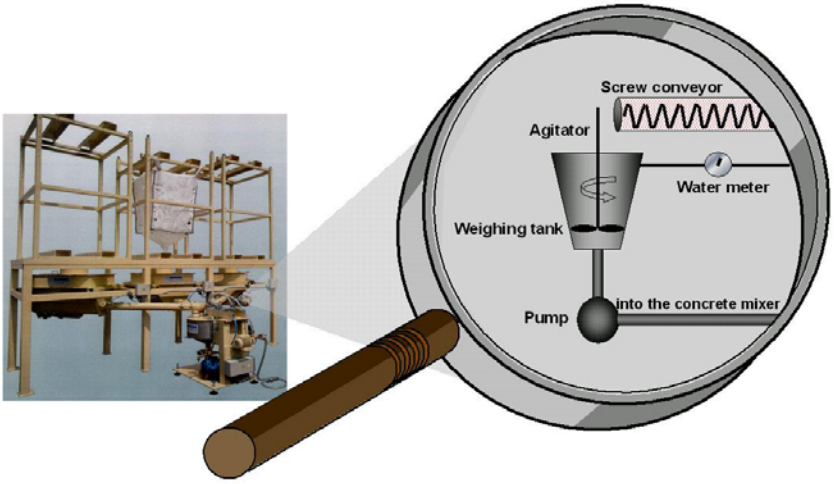

Fig. 5: Wet/Dry metering system

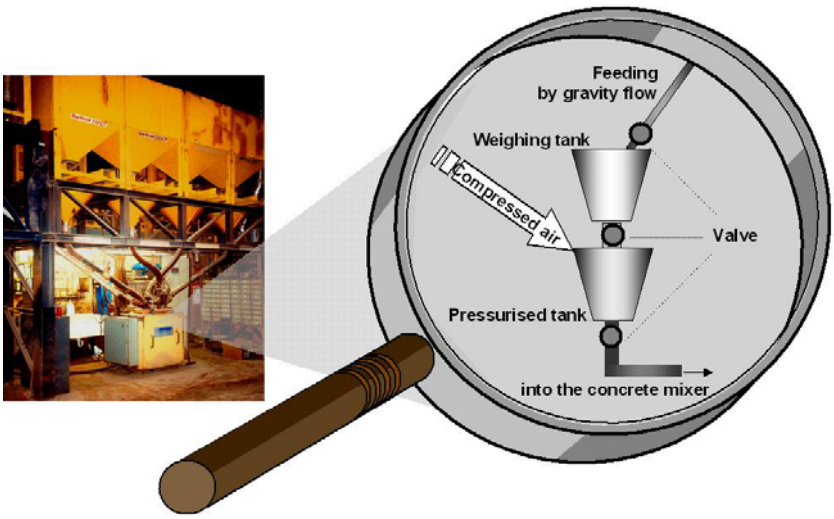

Fig. 6: Metering system for pigment granules

Pneumatic Metering

Along with new pigment supply forms – granules or compact pigments – completely new methods of pigment metering have been developed.

The most outstanding properties of the new product groups are their good flow characteristics and clean handling. For these reasons, manual addition remains an attractive alternative for users working with relatively small amounts of pigments.

Aside from the previously mentioned properties, the particle sizes of the granules and compact pigments are significantly larger compared to powder pigments. This makes them very well suited for compressed air – or pneumatic – conveying. New metering systems designed exclusively to handle these types of pigments came on the market at the same time as the new pigment products appeared. With these systems, the pigment granules move to the scales by gravity flow (see Fig. 6). Once the appropriate amount of pigment has been weighed, the scales are emptied into a pressurised tank, and the granules are conveyed to the concrete mixer by compressed air. In a

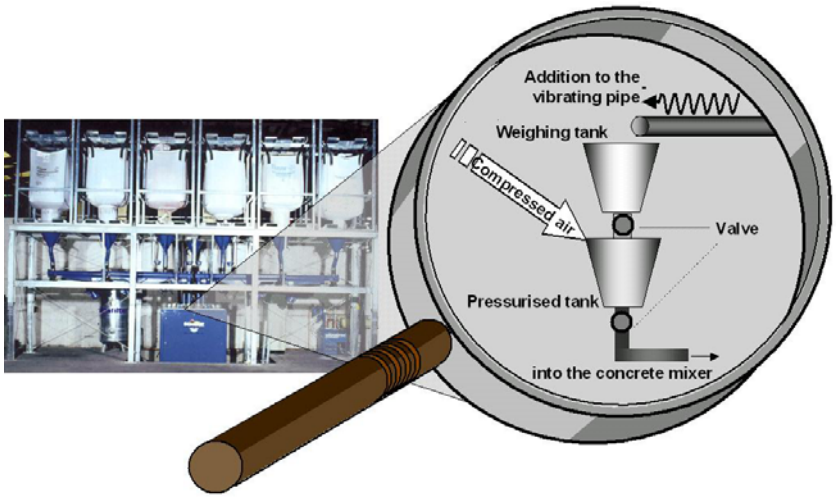

Fig. 7: Metering system for pigment granules and compact pigments

cyclone installed above the concrete mixer, the delivery air is separated from the pigment. This step is necessary to prevent the serious dust problems that would occur if the relatively large amount of air was to be blown directly into the concrete mixer.

Shortly after pigment granules came on the market, compact pigments (a new class of products with favourable characteristics) emerged. Although these pigments are in some aspects similar to granules, there are still certain differences between the two product groups. Because both types develop little dust and have good flow properties, they are well suited for use in units originally designed for powder pigments. Compact pigments can also be used in the liquid metering process.

However, practical experience showed that first-generation pneumatic metering units could not be operated safely with compact pigments. Further improvement of these units eventually led to systems able to handle conventional granules as well as compact pigments.

In these units, the pigment is conveyed to the scales through a vibrating pipe. The scales are emptied into a pressurised tank, and the pigment is transported into the concrete mixer by compressed air (see Fig. 7).

A special filter unit installed on the concrete mixer eliminates any dust emissions, including the emission of cement dust during the addition of cement (see Fig. 8).

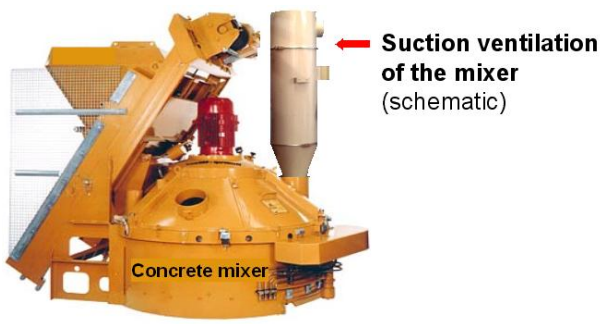

Fig. 8: Pneumatic pigment metering: dust removal from the mixer

Fig. 9: Compact, modular metering systems for compact pigments and pigment granules

The refined technology of these systems, in which the conveying of the pigments to the scales by gravity flow has been replaced by forced movement, has made a much more compact and space-saving design possible (see Fig. 9). Similar units without the pneumatic conveyor can also be used for pigment metering to the aggregate belt or to the bucket hoist (see Fig. 10).

The System Solution

In view of what has been said here, it becomes clear that each of the different metering methods has very specific advantages and, in some cases, also certain weaknesses. However, for those interested in this subject, it is not enough to examine only the different metering methods. It is also necessary to consider which of the pigment supply forms available on the market is the most advantageous in a particular situation.

There are no generally applicable guidelines that can be applied to decide which combination of pigment supply form and metering system is the best in each individual case. However, the following overview is an attempt to show the advantages

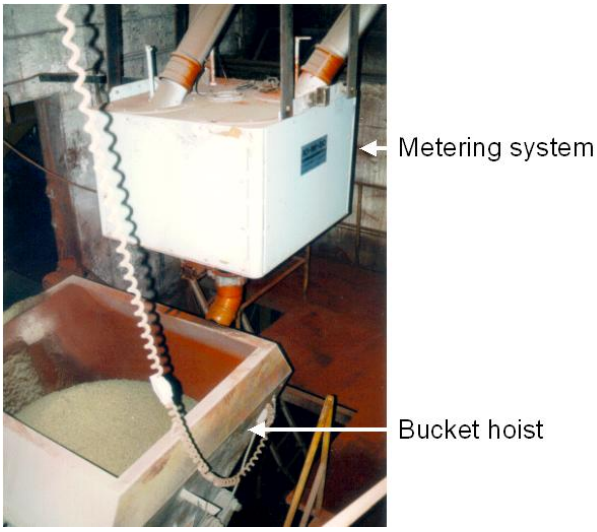

Fig. 10: Compact metering systems for compact pigments

and disadvantages of the various solutions in a simplified form (see Fig. 11).

When making the final evaluation, the local particularities as well as the different economic considerations at a particular plant should not be forgotten. Only careful weighing of these conditions can ensure that a decision will prove to be correct for the long term.

Literature

[1] Publications from the following companies:
- LANXESS Deutschland GmbH, D-47812 Krefeld
- Finke GmbH, D-32758 Detmold
- Gasus Dosier- und Foerdertechnik GmbH, D-97076 Würzburg
- KI MI DO Kindler GmbH, D-72160 Horb
- Wuerschum GmbH, D-73760 Ostfildern

[2] H.-H. Plenker, “Metering and Distribution of Pigments in Concrete” Betonwerk + Fertigteil-Technik (Issue 9/1991)

● Rating of positives
● Rating of negatives

		Cleanliness	Accuracy	Investment costs	Operating costs	Flexibility 1)	Concrete technology 2)
Mechanical metering system	Powder	●	●	●	●	●	●
	Granules	●	●	●	●	●	●
	Bayferrox C	●	●	●	●	●	●
Pneumatic metering system	Granules	●	●	◐	●	●	●
	Bayferrox C	●	●	◐	●	●	●
Wet/dry metering system	Powder	◐	●	◐	●	●	●
	Bayferrox C	●	●	◐	●	●	●
Slurry metering system	On-site slurry	◐	●	◐	●	●	●
	Pre-manufactured slurry	●	●	●	●	●	●

1) Flexibility of location
2) Possible influence on the water/cement ratio (wet sand)

Fig. 11: Advantages and disadvantages of the various metering methods