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Continual mixing and metering of liquid dyes and additives

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Overview

In the case of many production processes in the plastics-processing industry, the polymers used require dyes or additives. Dyeing polymers frequently takes place during the manufacture of films, pipes, profiles, etc., but also in the production of yarns. Here, it is common to use colored master batch granulates, which are usually added to the main polymer by means of gravimetric metering systems in the hopper zone of the extruder. The drawback of this method is that manufacturers must warehouse a separate master batch of each shade of the end product, which results in considerable warehousing and logistics costs. Furthermore, determining the pigment ratios of each individual master batch requires comprehensive preliminary trials to be carried out, whereby the master batch granulates must first be manufactured, followed by testing of the production process. Liquid dyes – which can be mixed continually during production – are an extremely efficient alternative to the above-mentioned utilization of dye master batches. This offers two decisive advantages:

- Manufacturers only have to stock a few basic dyes on the basis of which all final dyes are mixed. This substantially lowers warehousing and logistics costs.
- The color of the end product can be corrected during on-going production, which can significantly reduce time and costs.

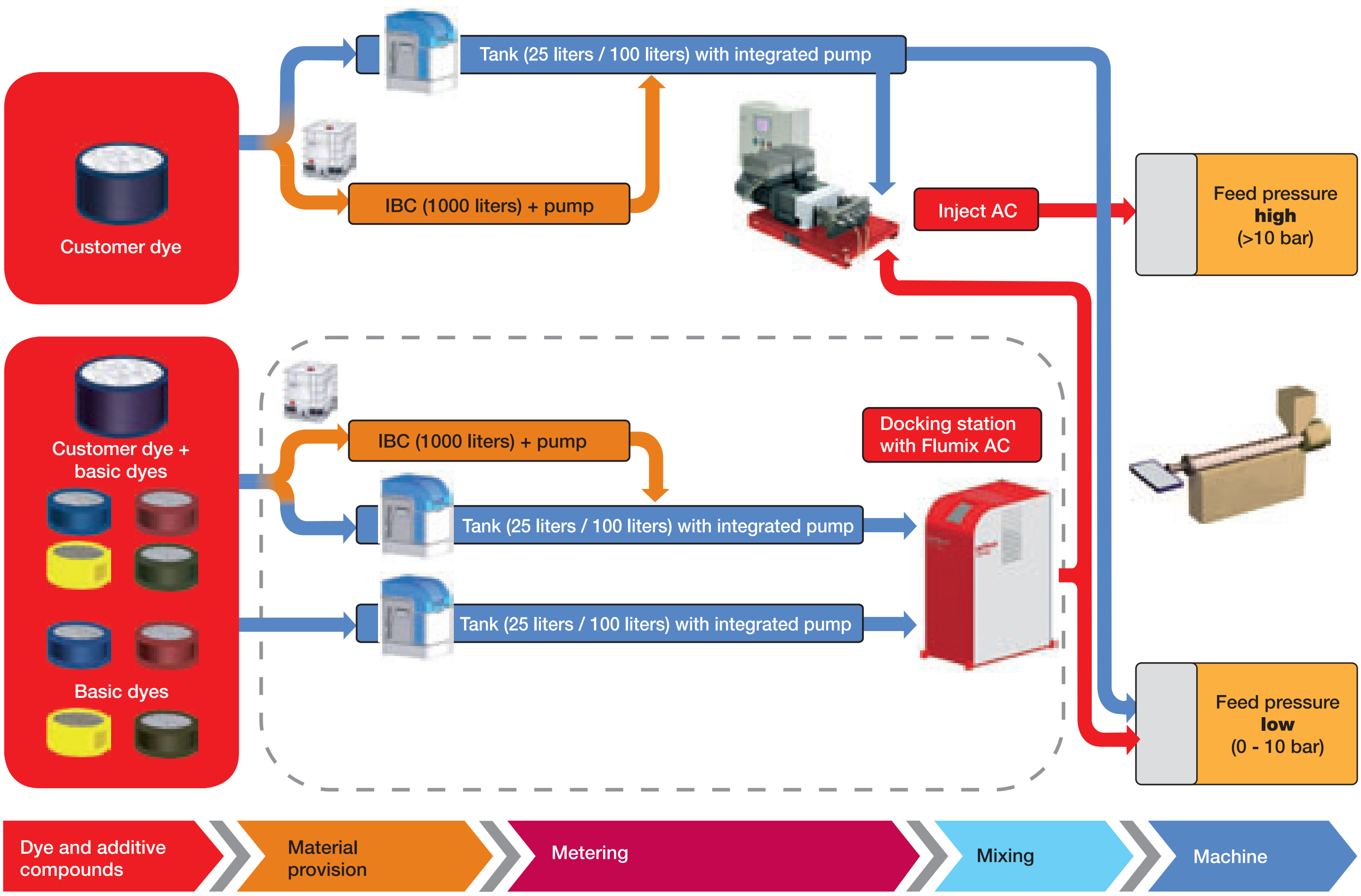

Figure 1: This flowchart graphically demonstrates the function of the Rainbow system

Rainbow system

Since 2002, Oerlikon Barmag has been collaborating intensively with Rowasol – a subsidiary of the Rowa Group. For mixing and feeding liquid dyes during the production process, Rowasol – in close cooperation with Oerlikon Barmag – developed the Rainbow system.

Depending on the customer request, Rowasol produces either pre-mixed customer dyes or basic dyes. These are filled into special tanks, each equipped with an integrated pump and a drive module. As soon as the dye within the respective tank is exhausted, the tank is returned to Rowasol, where it is refilled. This offers customers the benefit that they have no direct contact whatsoever with the dye and hence any contamination resulting from drops of dye is avoided. The tanks are connected to the downstream systems using drip-free quick-fitting couplings, hence ensuring that there is no possible contact with dye here either.

As an alternative to the 20- and 100-liter tanks IBCs (intermediate bulk containers) with a capacity of 1,000 liters are used. These are required for large-scale customer systems with high dye consumption. As the IBCs do not come with integrated pumps, they are coupled with an external pump unit.

Ready-mixed customer dyes can be metered directly from the tanks into the pressure-free area of the extruder (hopper zone) using the integrated pumps. If, in contrast, the customer dye is to be fed into the pressure zone of the extruder or in the downstream melt pipe, then the respective tank pump is connected to the Oerlikon Barmag INJECT AC high-pressure system. This is able to feed the customer dyes with high precision at pressures of up to 300 bar.

Using basic dyes achieves maximum efficiency. These dyes are conveyed to the Oerlikon Barmag-developed docking station by the tank pumps. In the docking station, all basic dyes are mixed in a dynamic type FLUMIX AC mixer to create the final dye. Then the final dye is directly metered into the pressure-free zone of the extruder by the tank pumps or fed into the pressure zone of the extruder or into the melt pipe using a downstream INJECT AC system. The docking station is the central unit of the entire system; it not only controls its own components (FLUMIX AC mixer, valves, etc.), but also controls the tanks connected to it including the integrated pumps.

Feed points

The dyes or the additives can be fed in at three different points within the production system:

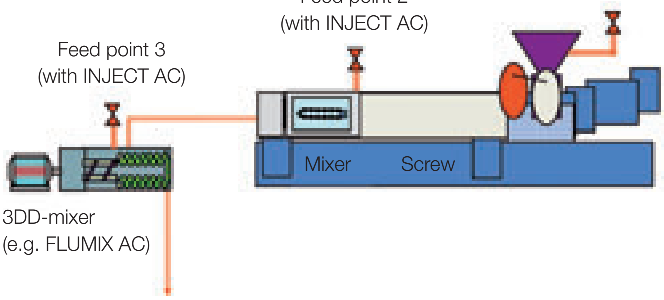

Figure 2: Feed points

The easiest option is the pressure-free addition of the dye to the hopper zone of the extruder (feed point 1). Here, the dyes are fed by the pumps integrated in the tanks and are mixed into the plastic melt using a dynamic mixer, which is designed as an extension of the extruder screw. However, feeding the dye in the hopper zone of the extruder has two major disadvantages: firstly, the extruder no longer evenly draws in the plastic granulate if certain dye volumes are exceeded and, secondly, the entire production system – including the extruder screw – comes into contact with the dye, which makes the dye change times extremely long.

In the event that the extruder is equipped with an effective dynamic mixer – for example, one in accordance with the 3DD principle – the liquid dye can also be directly metered upstream to the mixer using the INJECT AC system (feed point 2). Adding the dye at this point has the advantage that the extruder screw has no contact with the dye, which shortens the dye change time. A drawback is the fact that a large part of the melt-conveying areas – in other words, the melt pipe, potentially a booster pump and a filter – come into contact with the liquid dye, which has a negative impact on the dye change times. Furthermore, the mixer and the extruder screw are directly connected to each other, hence prohibiting separate setting of the mixer speed.

The ideal method is to feed into the melt pipe area (feed point 3) using the INJECT AC. Here, the INJECT AC system should be connected as closely upstream to the nozzle (for instance in the case of cast films or pipe systems) or upstream to the spinning pump (for spinning systems) as possible, which results in dramatically shorter dye change times. Mixing the dye into the melt sufficiently homogenously requires the installation of an effective dynamic mixer, the preferred choice being the Oerlikon Barmag FLUMIX AC type. These come with a connection for the liquid dye and can be individually set to the respective operating point via the mixer speed.

Figure 3: INJECT AC system

INJECT AC system

Feeding dyes or additives under pressure (feed points 2 or 3 in Figure 2) requires the use of high-pressure type INJECT AC metering systems. These are able to meter even thin-fluid media – such as liquid dyes and additives – at pressures of up to 300 bar. Metering is carried out with 100% accuracy. To achieve this level of precision, the INJECT AC systems are equipped with two pumps connected in series. The first pump builds up the required pressure, while the second pump meters without any volumetric loss.

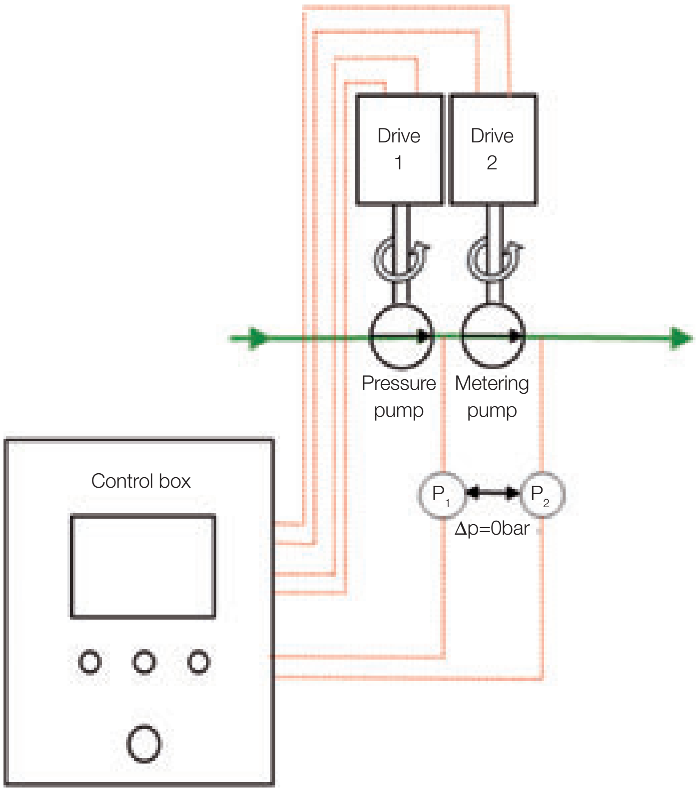

Figure 4: Function of the INJECT AC system

The required dye or additive throughput is set on the touch-screen of the INJECT AC control box. On the basis of this value, the system calculates the speed of the metering pump and sets the corresponding drive accordingly. To ensure the pump meters with the required precision of 100%, the pressures at inlet (p1) and at outlet (p2) of the metering pump must be identical. To guarantee that this is the case, pressures p1 and p2 are measured and compared with each other. The speed of the pressure pump is automatically set so that pressure p1 is identical with to pressure p2. In the event that system pressure p2 changes, pressure p1 follows in less than 0.5 s, without any control-technology oscillations occurring.

Docking station with integrated FLUMIX AC mixer

The "core" of the Rainbow system is the docking station, which assumes two key functions: it mixes the basic dyes and controls all components involved.

Up to six tanks with various dyes or five dye tanks and a detergent tank can be connected to the docking station at any given time. These are connected on the rear side of the docking station by means of drip-free, self-closing quick-fitting couplings.

Docking station

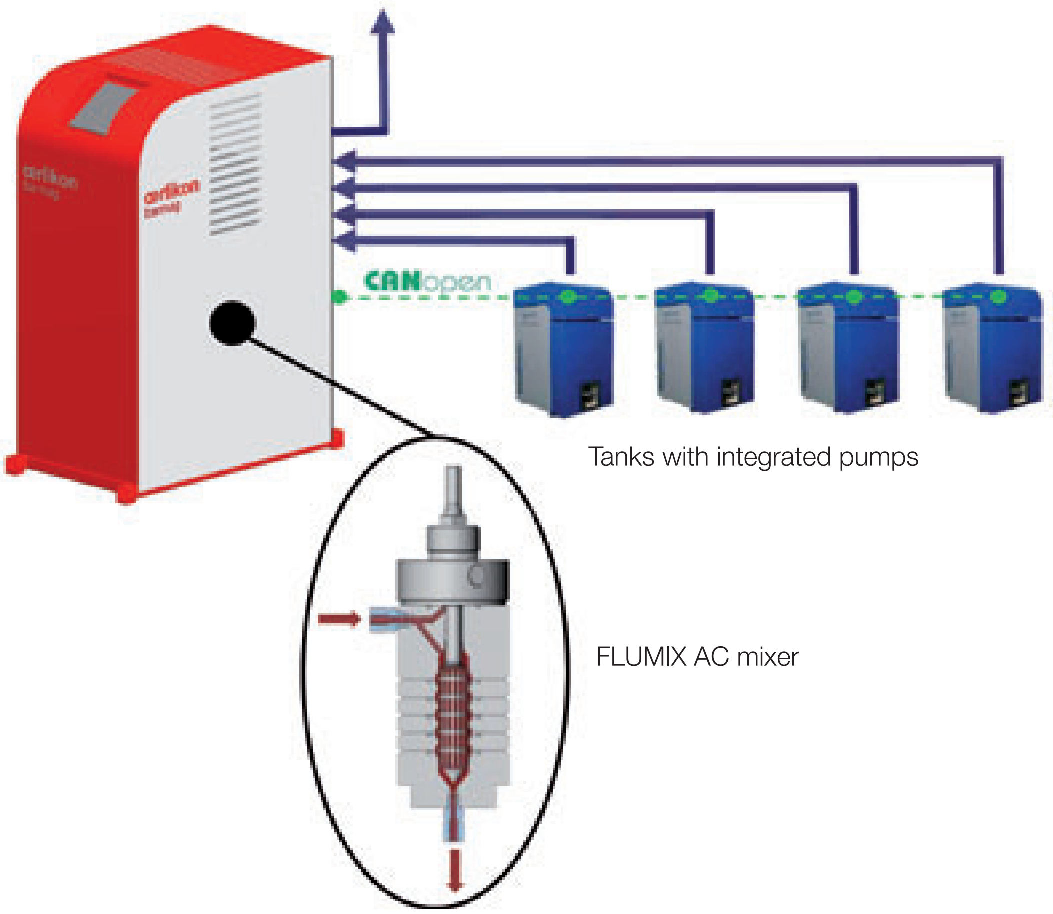

Figure 4: Docking station with FLUMIX AC mixer and connected tanks

Inside the docking station, the dyes are brought together in a valve block, which comprises six individual valves that are automatically opened for all those dyes involved in the respective formulation. Valves for dye lines not connected to tanks remain closed, so that there is no carry-over of dyes from these lines.

From the valve block, the merged dyes are fed into the FLUMIX AC type dynamic mixer via a collector line. The mixer works in accordance with the proven 3DD principle and mixes the individual dyes absolutely homogenously to create the required final dye color. The speed of the mixing rotor decisive for the mixing performance is automatically set by the docking station's control unit depending on the respective dye volume flow.

A particular advantage of the FLUMIX AC mixer is its self-cleaning capacity. After switching to a different formulation, it takes merely a few minutes before the residue of the previously produced dye has been completely flushed out of the mixer.

To further speed up the cleaning process for the mixer and other components that have had dye flowing through them, the operator has the possibility of triggering an automatic rinsing cycle prior to starting a new formulation. Here, the control unit activates a valve that connects the dye line with a collection container. Subsequently, the entire system is flushed through, whereby the rinsing medium used is either the dye for the next planned formulation or a special detergent. Compared to the throughputs during normal operation, the throughputs of rinsing dyes or detergent are considerably higher.

The docking station is equipped with a color touch-screen and a control box. The touch-screen is used for setting and saving various dye formulations required for the production process. Furthermore, the desired dye volume flow (in other words, the dye feed volume) is set. In addition to this, all system parameters are set and saved using the touch-screen and the dye outlet pressure, for example, is constantly displayed.

Starting a previously-stored formulation triggers several processes: via the CANbus system, the various dye tanks are automatically activated and the pumps integrated into the individual tanks are set to the respectively required speed. The speed of the mixing rotor is also automatically set by the control unit – dependent on the prescribed dye volume flow. Furthermore, the valves of the dye lines required for the respective formulation are opened.

If operators detect during production, that the end product (for instance cast films) does not have the desired dye color corrections to the formulation can be made without the system being stopped. The results of these corrections are visible in the end product after only a short time. This provides tremendous time and cost benefits vis-à-vis dye master batches, as dye corrections for master batches can only be carried out by means of the costly and time-consuming manufacture of new batches.

If the docking station also has a downstream INJECT AC system connected, operators have to activate the pressure control using the docking station's touch-screen. This enables the INJECT AC system to define the dye volume flow. The pressure control allows the adjustment of the tank pump speeds so that the dye outlet pressure of the docking station maintains a constant preset value. Needless to say, the respective formulation is not changed here; in other words, the percent ratios of the dye volumes delivered by the individual tanks must always remain constant.

Summary

The Rainbow system permits the plastics-processing industry to continually mix liquid dyes and additives during the production process and to feed these into the process either pressure-free or under pressure. Oerlikon Barmag developed two essential components: firstly, the INJECT AC high-pressure metering system and, secondly, the docking station with its integrated mixing unit.

The INJECT AC system is a metering unit that has been successfully deployed in production facilities for many years now and is used for metering fluids into plastic melts with a high degree of precision and at pressures of up to 300 bar.

The docking station is a completely new development, which will be delivered to the first customers in June 2011. It comprises a dynamic FLUMIX AC type mixer and a complex electronic control unit, allowing it to continually make up liquid dyes – based on saved formulations – during the production process. For this, up to six tanks with integrated pumps and containing the required basic dyes are connected to the docking station. The dye change time – in other words, the time required to completely rinse out all traces of the previous dye formulation – takes just a few minutes.

The dye being fed into the extruder's pressure zone or in the downstream melt line using the INJECT AC system prevents the extruder screw and potentially further components, such as booster pump and filter, coming into contact with the dye. Therefore, color changes can be carried out in considerably less time than if the dye had to be added in the hopper zone of the extruder – hence, considerably reducing production costs.

Using the docking station and the associated continual mixing of the dye during production can lead to considerable savings: manufacturers no longer need to stock all production dyes, but merely a few basic dyes. Furthermore, corrections to the dye formulation can be carried out during production, so that the result of the dye adjustments can been seen in the end product even after just a short time.

Using the INJECT AC system – and, above all, installing the docking station – can significantly reduce the production costs, resulting in very short return-on-investment periods for these components.

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