Preface

Modern production of polymers requires flexibility and fast adaption to changing market demands. The necessity of adding substances like modifiers, masterbatches, compounds and other additives to the polymer on the rise to able to supply also niche products in a competitive market environment. How can these substances be added, especially to direct production lines – from raw material to final product? The requirements for a producer are:

- Tailor-made design for a wide range of meltable or liquid additives, polymers and masterbatches.
- Consistent, throughput-controlled dosing accuracy
- Excellent mixing performance
- Wide throughput range
- Individual melt modifications for special products manufactured at selected production positions
- Modular design and interchangeable components
- Minimum waste and downtime during product changes
- Ease of operation and additive handling
- Low investment and operational costs

To meet these requirements, three different ZIMMER® dosing technologies have been developed.
I. COmpact METering and mixing system - COMET

With the COMET system, two different principles for mixing have been realized:

- Direct injection system
- Premixing injection system

COMET is designed for metering and mixing a masterbatch, an additive or a copolymer to the polymer inside the product piping. For example in textile filament plants the polymer is distributed through piping branches to numerous winder positions ranging from, say, 8 in extruder spinning plants to more than 600 winder positions in direct spinning plants. Based on capacity and process requirements, COMET can serve all or only a selected number of winder positions (Fig. 1). Most common dosing rates vary from 0.4 to 6 wt.-%.

COMET is divided into a metering unit and an injection mixing unit. The metering unit is common for both mixing principles and includes a vacuum conveyor, dryer, extruder, metering pump and the control panel. It is of compact design and can easily be placed next to the injection-mixing unit and both units are simply connected by a tube.

Fig. 1  COmpact METering system COMET
**Direct injection system**

The direct injection system is the basic design to be applied for easily dispersed additives like masterbatch. A piston valve enables opening and closing the injection nozzle for on/off metering.

The injection-mixing unit is connected to the product pipe in a rectangular bend. It consists of a piston valve and a static mixer column. The extruded additive is metered by the gear pump and enters the product pipe through the piston bore, which is neatly closed off by a piston during off-metering operation. The static mixer arranged downstream of the injection nozzle is of customized layout. Extruder and gear pump are mounted on a skid slide which enables the separation of both units within a few minutes for flushing or calibration purposes. Quick interchangeability without interrupting production whenever the metering operation is switched on or off and close-coupled polymer routing offer distinctive advantages for this system. The system is controlled by a Windows NT-based PC linked to the actual plant throughput and the plant control system.

**Premixing-injection system**

The premixing injection system is suited for additives which need a higher degree of dispersion.

For this design, a planetary gear pump replaces the inline gear pump. Instead of a piston valve, a premixing head is flanged to the product pipe in a rectangular bend.

The premixing head consists of the planetary gear pump, a two-stage static mixer (mixer 1 and 2), the injection nozzle and an adapter plate for adjusting the on/off metering operation.

The planetary gear pump is of special design as it runs counterclockwise. Inside this pump six planetary gears are driven by the sun gear. Every planetary gear is provided with an inlet and outlet bore. At the inlet bore the stream is divided into half between the planetary and the sun gear. One of the six inlet ports is fed with the additive while the other ports are served with polymer from the main product pipe. Adjacent to the additive inlet bore, the outlet bores at the two neighboring planetary gears discharge additive and polymer at a volumetric ratio of 1:1 as half of the portion comes from the planetary gear and the other half portion discharges from the sun gear. The remaining four outlet bores discharge only pure polymer. The two pump outlet bores carrying the premixture additive-polymer join in the static mixer 1. Downstream of Mixer 1 the premixture (mixing ratio 1:1) is mixed again in Mixer 2 with additional polymer from the remaining four pump outlet bores. Finally, the resulting premixture with a volumetric mix ratio of 1:5 is injected into the main stream where mixing of the whole compound is accomplished by a static mixer column.
The metering pump and mixers are combined directly with the product pipe resulting in a very short residence time which is favorable for degenerating additives. In-line but also planetary metering pumps of various capacities are largely interchangeable within the same unit. COMET is of modular design. The components are standardized for volumetric dosing rates from 2 to 700 cm³/min. Static mixers are selected considering desirable shear rates and limited pressure drop in the polymer line.

II. Inline CCompounding System - ICOS

The ICOS is designed for directly adding a powder type additive to the polymer.

For large-scale polymer production it is becoming increasingly necessary to add TiO2 downstream of the final reactor. Other additives like flame retardants or colors can also be added to the polymer either upstream of the chip cutter or on the way to the spinning systems.

Fig. 2 shows that a side stream of the main polymer line is transferred to a kneader by means of a metering pump. The powder type additive is dosed to the kneader by gravimetric dosing. The kneader mixes the additive and the side stream polymer very well before it is returned to the main polymer line by a booster pump. In the main polymer line, the complete product including the powder type additive is treated in a special static mixer to ensure uniform mixing of polymer and additive.

This is the principle of the above mentioned pre-mixing version of the COMET. Like in the COMET system, the side stream can be readily separated by valves to allow for an easy change of additives, maintenance and start-up.

Instead of metering the polymer side stream with additive back to the main polymer line, it is also possible to produce masterbatch chips downstream of the kneader (see figure 2).

The advantages of the ICOS are

- Excellent particle distribution in the polymer
- Low particle size of the additive and no agglomeration
- No settling of particles directly after melting the masterbatch and before entering the side stream polymer
- Normal pressure build up in the spin pack
- Good spinning performance

Normally, TiO2 is compounded at about 20 wt.-% into PET and diluted afterwards to the desired concentration for the downstream process. To avoid a drop in viscosity, e.g. SACHTLEBEN offers its new product FPP TiO2.
III. Compact Liquid Additive System - CLAS

As already mentioned in the preface, the polymer industry is increasingly asking for tailor-made products. Small lot sizes compared to the total plant output of one plant section and a quick change of additives producing a minimum of off-spec material are the prerequisites for an economic and profitable production.

This can also be achieved by the CLAS dosing system for adding liquid additives to the polymer melt in any product stream. Injection of liquid components into a pressurized melt system cannot simply be accomplished using an injection lance. Once the lance fills with polymer due to the system pressure in the melt line, it becomes impossible to inject the liquid additive into the melt. A planetary pre-mixing pump prevents this. Dosing of liquid components can be switched on and off at any time without causing irregularities. Short residence times in the hot phase required for some special additives can thus be achieved.

Fig. 3 illustrates the principle of the compact liquid additive system CLAS.
Advantages:

- Dosing of low viscosity additives into polymer melt (viscosity of liquids or suspensions: 20 – 100 mPas)
- Precise volumetric dosing by gear pumps
- Uniform mixing of polymer melt and additive with the help of a premixing planetary gear pump and downstream static mixer
- No backflow of polymer melt into the dosing system when it is switched off
- Easy start and stop function even at high melt pressure
- Backflow of low viscosity additives into the pre-mixing gear pump is avoided by a pre-pressure pump
- It is possible to connect a flow-meter to the dosing pump drive. This ensures dosing consistency and avoids time-consuming calibration.

Summary

The dosing of additives is a complex challenge. Liquid or solid additives, colors or masterbatches have to be mixed into the polymer in different stages of the process. Zimmer® technologies provided by Lurgi meet this challenge. With the dosing technologies Comet, Icos and Clas all demands of modern polymer production can be fulfilled.