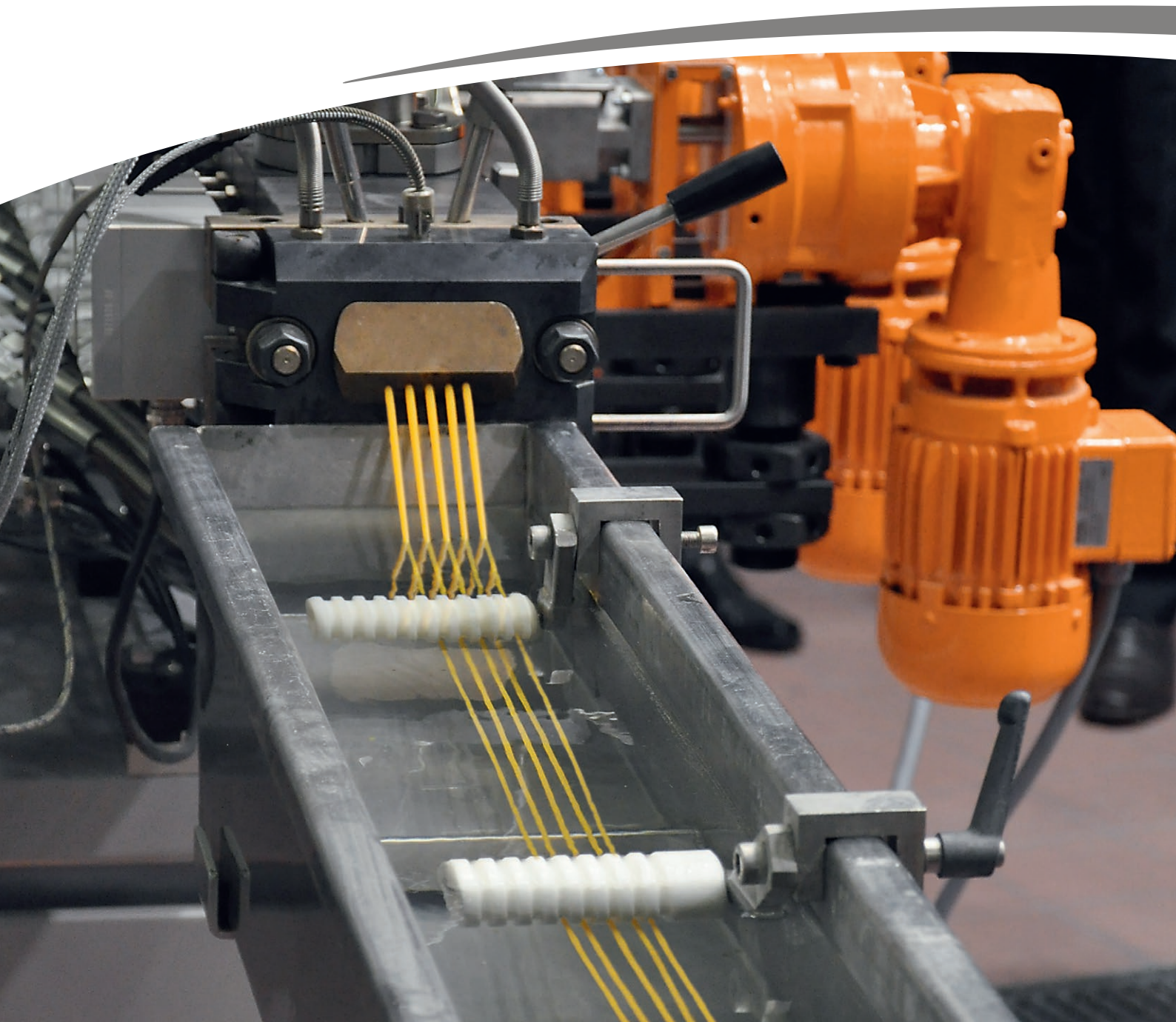


MASTERBATCH PRODUCTION

Extruders and extrusion lines



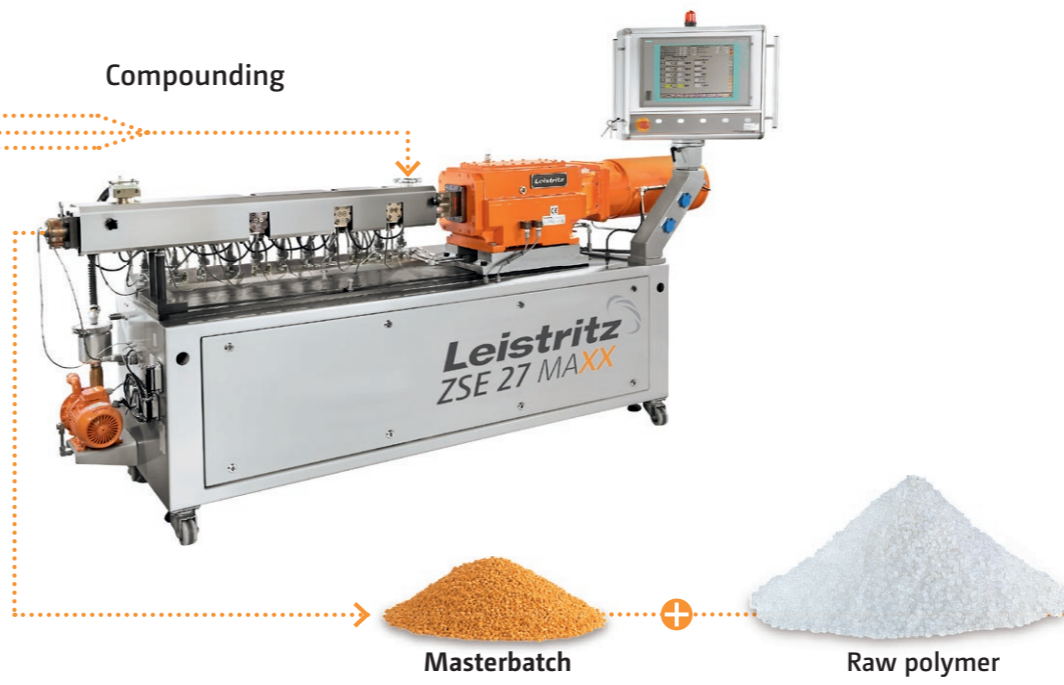
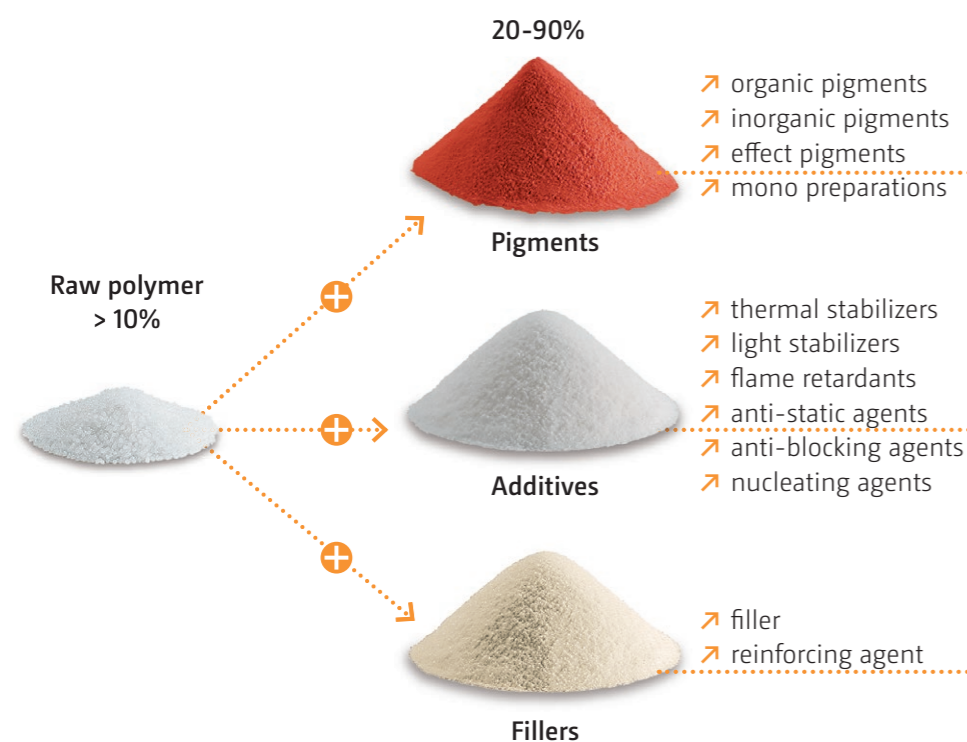
MASTERBATCH – THE GRAIN MAKES THE DIFFERENCE

Small, but with a major impact

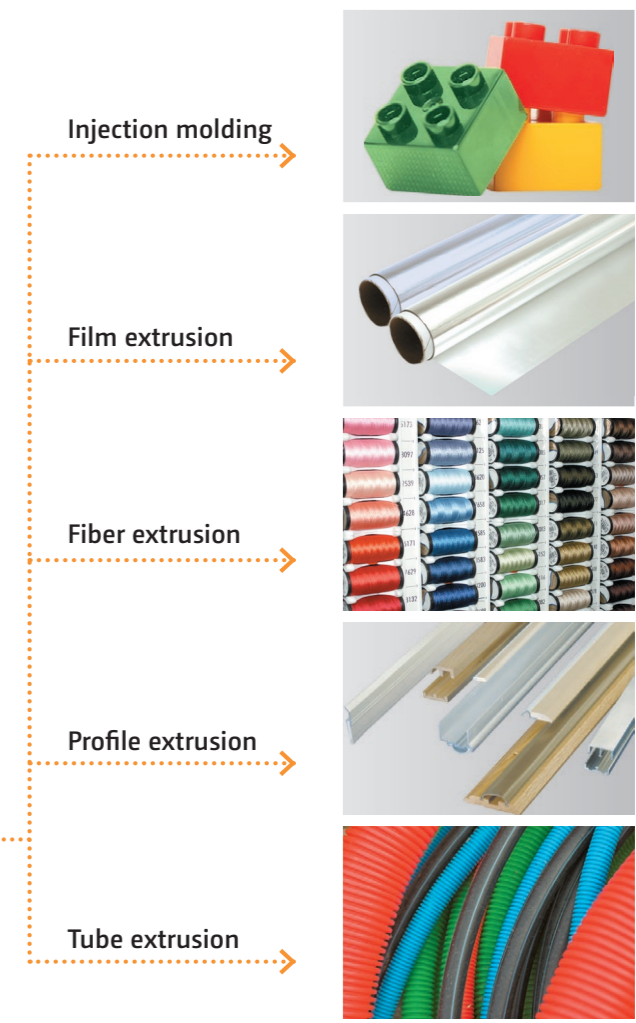
Plastic pellets with a high share of pigments and/or additives that is much greater than in the final application are called masterbatches. In later process steps such as injection molding, film or fiber production, these are added to the raw polymer to color this or to specifically change other properties.

Compared to pastes, powders or liquid additives, the use of a masterbatch improves the process reliability on

account of the precisely defined share of pigments in individual pellets. A further advantage is that the masterbatch is very easy to process because it does away with the handling of large amounts of powder. It's use is also beneficial from the point of view of environmental impacts and workplace pollution.



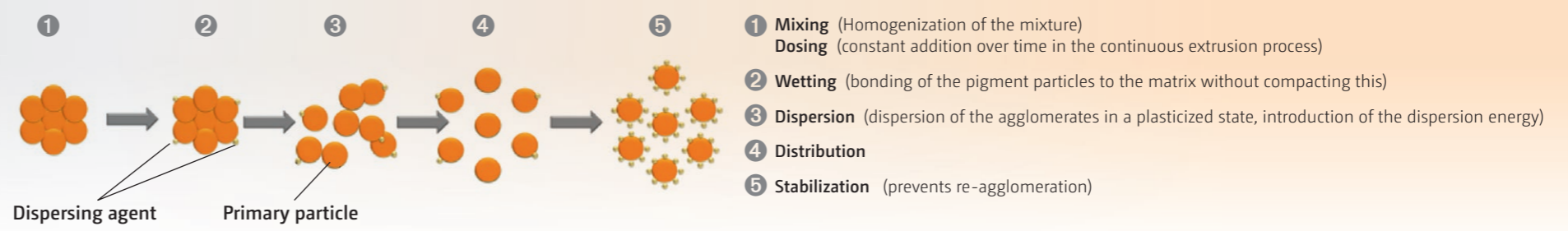
- ONE GENERALLY DISTINGUISHES BETWEEN THREE MB GROUPS:
- **Color Masterbatch**
→ is used to color plastic products
 - **Additive Masterbatch**
→ ensures certain chemical and physical properties of the final products (e.g. UV-stabilization, flame-retardant, anti-static)
 - **Filler Masterbatch**
→ contains a high share of fillers such as CaCO₃



Important: the correct dispersion

The goal when manufacturing masterbatches is the optimum dispersion and distribution of the additives in the polymer matrix. This is carried out after wetting by the mechanical energy introduced by the screws. If this takes place too early in the process, the un-moistened pigments can be compressed back into agglomerates by the force exerted on them (cold agglomeration). Two processes can be used to produce a masterbatch: premix* and split-feed**.

*see P. 8/9 ** see P. 10/11



COLOR MASTERBATCH

Knowledge of the right color

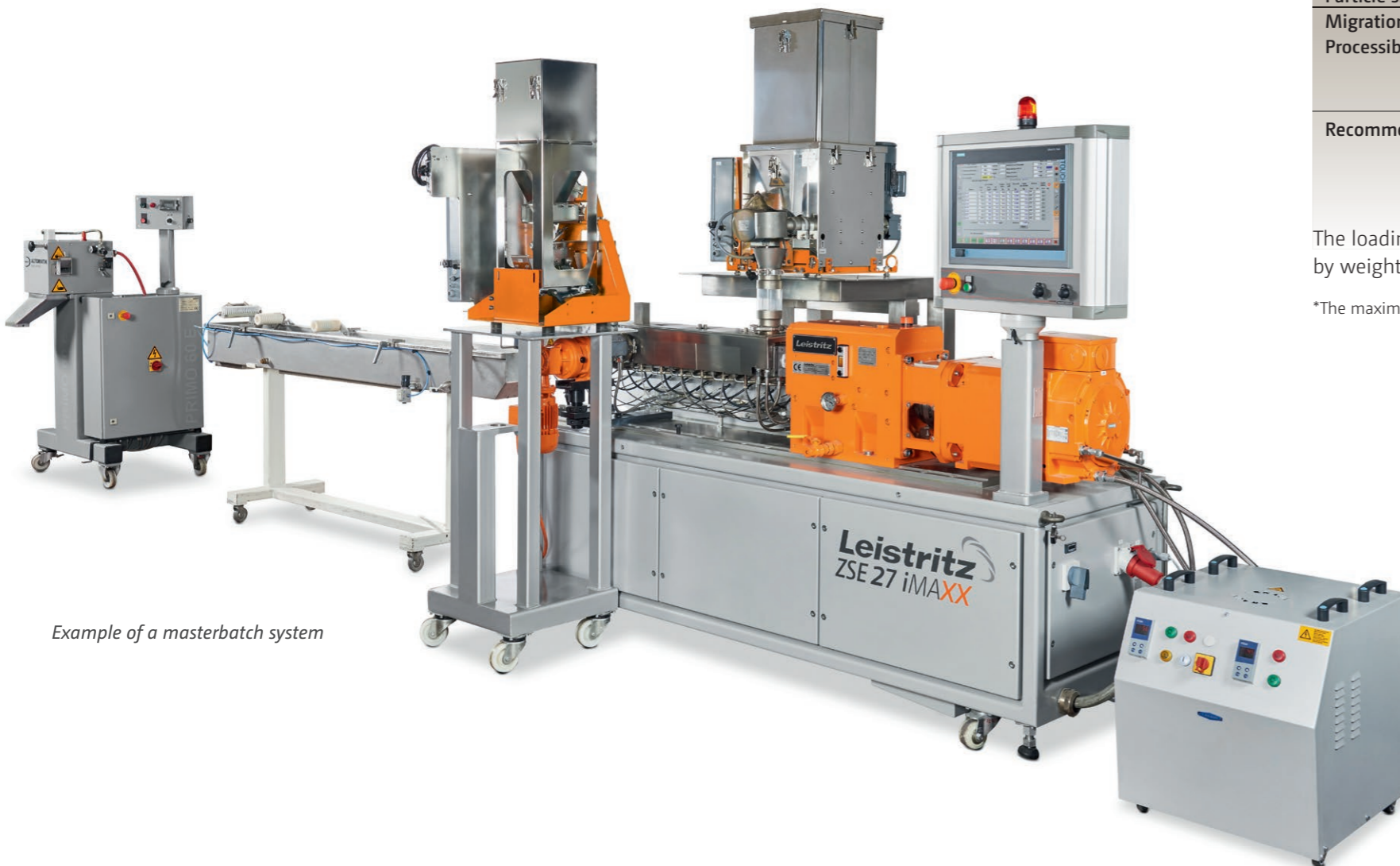
Color masterbatches can be divided up into roughly the following types:

- Mono batches or "Single Pigment Concentrates" (SPC): Masterbatches from a certain pigment and a supporting base; wax and/or dispersing agents are often added
- Customized masterbatches: bespoke formulations, mixtures of various powder pigments
- Custom Coloring: mixture of different SPC granules to produce precisely the color the customer wants

The main benefit for manufacturers by using co-rotating twin screw extruders is the **very good quality of dispersion**. This is the basis for a high quality masterbatch. The two co-rotating screws that engage with each other **produce a self-cleaning effect**. This allows fast cleaning and consequently a **more rapid change** of product. Another advantage of co-rotating twin screw extruders is the modular design of the screws and barrels, which, depending on the process, **enables a fast set-up and conversion of the processing unit**.

Color masterbatches largely consist of individual color pigments that are combined to produce a specific target color. Other components may include effect pigments, dispersing agents and additives. Their production places great demands on the dispersion process because raw materials with different properties have to be optimally

incorporated in only one process step. What is crucial here is a knowledge of the properties of the pigments used (coloristics) and great expertise with respect to the extruder's process parameters.



Example of a masterbatch system

	Organic pigments	Inorganic pigments	Effect pigments	Mono preparations
Particle size	0.01 – 0.1 µm	1 – 20 µm	2 – 180 µm	very different: from very small to large
Particle shape	isometric	isometric	Platelets	depending on pigment
Migration resistance	+	++	no data	depending on pigment
Processibility	more dispersion energy needed, difficult to disperse	little shearing, easy to disperse, sometimes abrasive	sensitive to shearing – lowest possible shearing forces, highest possible mixing effect	fully dispersed, hardly any shearing needed, fuse and distribute
Recommended process	Premix and split-feed* possible	Premix and split-feed* possible	Split-feed*	

The loading concentration* for inorganic fillers ranges from 40 - 8 % by weight, and for organic pigments from 30 - 60 % by weight.

*The maximum load depends amongst other things on the application and base material.

» The ZSE MAXX twin screw extruder from Leistritz is at the heart of hundreds of systems worldwide. The products manufactured with this satisfy even the highest quality demands. «



ADDITIVE MASTERBATCH

Optimization of properties

Additive masterbatches can be used in a wide variety of applications. They can be used to modify the physical and chemical properties of plastics, e.g. the UV- or flame-resistance, thermal stability or impact strength. The polymer is hereby enriched with large amounts of liquid or powder additives.

Powder additives with a low bulk density such as silicate are usually added by means of one or two side stuffers for incorporation. The lower-cut screws in the Leistritz LSB XX side stuffer also help the feed of the material. The high free volume of the ZSE MAXX twin screw extruder

(OD/ID = 1.66) means that there is enough space in the process chamber to ensure a good dispersion and high throughput.

The additive feed often poses a challenge in processing: if additives with a low melting point are added, they could already melt in the side stuffer. This would lead to a blockage in the side stuffer. The formulation consistency can then no longer be guaranteed. In such cases, the use of a side stuffer with cooled barrels and screws (Leistritz LSB XX side stuffer*) is recommended.

*see accessory units P.13

IMPORTANT PARAMETERS FOR THE RESIDENCE TIME

On account of different viscosities and in some cases difficult mixtures, the residence time has to be increased for certain formulations. This is achieved by

- extending the processing unit
- the use of reverse screw elements

FILLER MASTERBATCH

Low-cost polymer substitute

Highly-filled masterbatches contain more than 50 % by weight of fillers that are dispersed in a polymer matrix. Different process set-ups are possible depending on the type and amount of filler. The most common fillers include calcium carbonate or talcum. Filler masterbatches are primarily used to optimize and increase the stiffness, reduce shrinkage and improve the surface appearance of the final product.

Application example:

CaCO₃ (70 – 85%) in polyolefin

There are two main reasons why CaCO₃ is used in plastic: it acts as a functional filler or mineral modifier (e.g. to produce breathable films) or it is used to reduce the costs of the compound.

What is important when using CaCO₃ is its very good incorporation in the polymer matrix. Coated CaCO₃ types are the most suitable because the surface coating adjusts the surface tension of the mineral to that of the polymer, greatly facilitating its incorporation and dispersion.



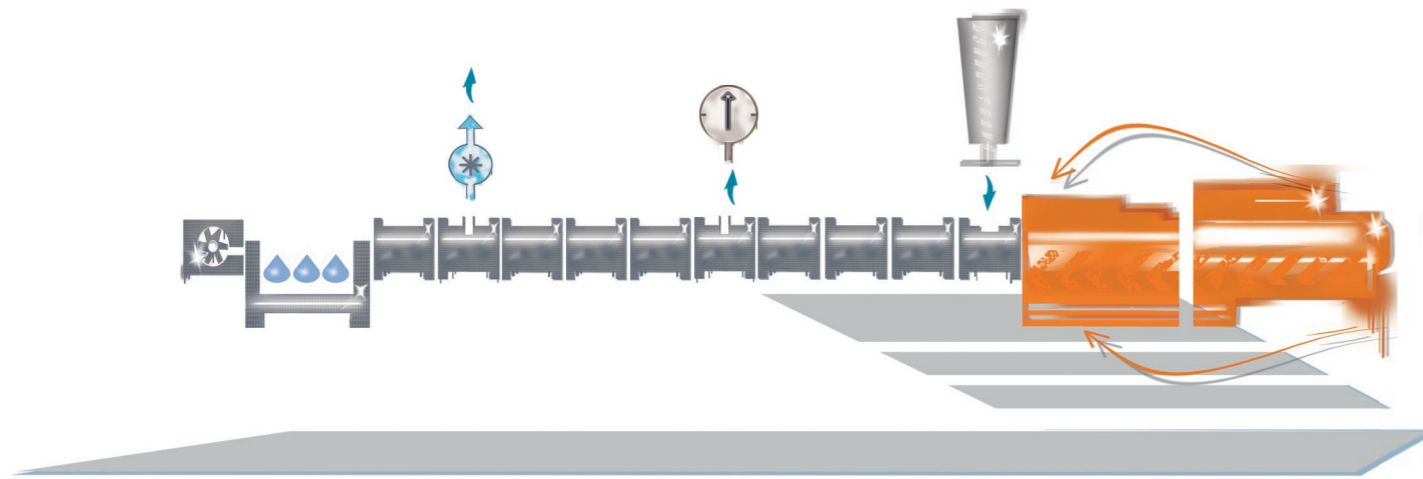
Example of a filler masterbatch system

PREMIX PROCESS

Metered addition of a premix

The process set-up shown here is suitable to produce both a masterbatch of mono pigments (SPC = Single Pigment Concentrate) as well as customized masterbatches of powder mixtures. All components are mixed in advance if the premix process is used. The quality of the masterbatch is determined largely by the preceding

mixing process. This is why this process step is extremely important: if the premix is not good, e.g. if agglomerates have formed, this fault cannot be remedied in the extrusion process.



Example of a possible cylinder set-up for the premix process

In this, the most widespread production process, the extruder is fed with a premix of the polymer, pigment and dispersing agent through the main feed opening and the feed cylinder. Since volumetric metering is possible, this means not only a high operational reliability but also uncomplicated handling. Venting is carried out a few cylinders further along so that the air introduced with the premix can escape. The screw geometry in the fusion zone should be chosen in such a way that not only is the complete mixture fused, but also the pigment is sufficiently wetted.

This is then followed by the actual dispersion zone. The extruder can be adapted to various requirements by altering the number of cylinders depending on the desired quality of the masterbatch. A masterbatch quality for injection molded parts can be produced with a short dispersion zone depending on the quality of the mixing. The highest quality demands, for example film or fiber products, on the other hand call for a long dispersion zone. The dispersion zone is followed by vacuum degassing and the discharge zone. A conventional pelletizer is used in the majority of cases.



ADVANTAGES OF THE PREMIX PROCESS

- lower investment costs than for split-feed (use of gravimetric systems, no side stuffers) through the use of volumetric dosing
- high pigment and additive loading possible
- easier cleaning (only one dosing unit)

» The be all and end all for a high quality result in the premix process is optimum premixing. «

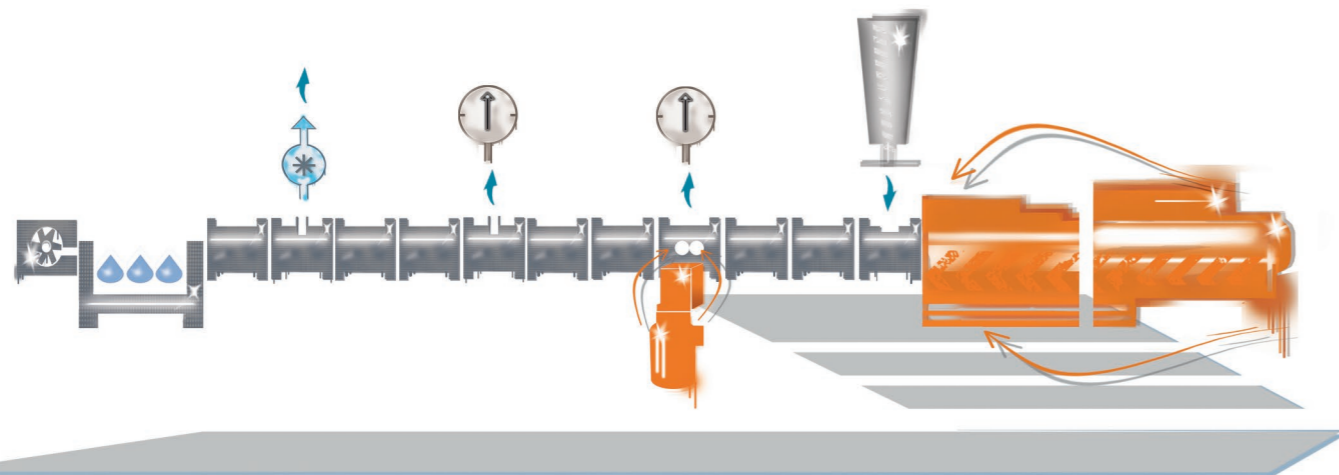
SPLIT-FEED PROCESS

Material feed through several dosing units

As an alternative to premix, both mono as well as customized masterbatches can be produced by the split-feed process. The material flows are hereby separated.

Through a separation into two or more material flows, the split-feed process allows processing of shear-sensitive pigments (e.g. effect pigments) or pigments

with a great tendency to compact (e.g. certain phthalo pigments) too. The energy needed to melt the polymer is introduced directly into the polymer - without the pigment - in the split-feed process. The pigment therefore experiences a lower physical stress.



Example of a possible barrel set-up for the split-feed process

With this version of masterbatch production, the polymer, and possibly smaller amounts of additives, are introduced into the process through the main feed opening and then plasticized. It is important that the polymer is 100 % molten before feeding the pigment through one or two side stuffers. Only then can the subsequent wetting zone work. All components in the formulation are fed into the process by gravimetric feeders. Unlike in the premix process, wetting can be somewhat softer in the split-feed process since the polymer is already molten at this stage. The masterbatch melt is stabilized and discharged after distributive and dispersive mixing.

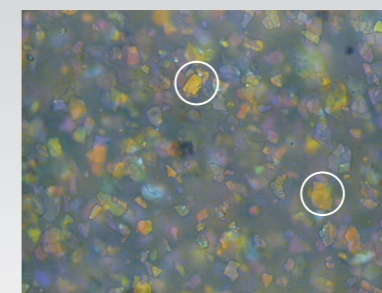
ADVANTAGES OF THE SPLIT-FEED PROCESS

- easy handling of the formulation via the extruder or feeder control system
- no complicated premix steps facilitates the production of larger mono batches
- allows the gentle incorporation of shear-sensitive pigments

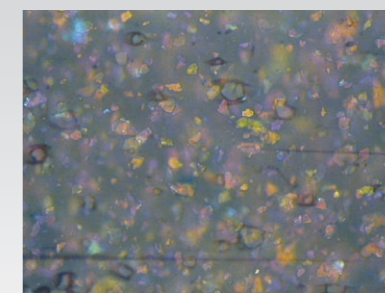


SPLIT-FEED PROCESS WITH EFFECT PIGMENTS

Some effect pigments have a layer structure consisting of platelets with a high surface relative to the height of the particle. Since the surface layer of these pigments can be easily damaged and they can thus lose their pearl luster, flop or shimmering colors, they have to be incorporated into the molten polymer matrix very gently. The appropriate process is thus split-feed. The melt mobilizes the platelets when they are added and largely prevents their destruction by the kneading and conveying elements of the screw. The viscosity of the melt dissipates the agglomerates and makes for an optimum development of the effect. Important: mixing here is distributive, not dispersive.



Split-feed, ZSE MAXX



Premix, ZSE MAXX

Effect pigment based on mica in a polymer matrix; larger particles with split-feed → better quality.

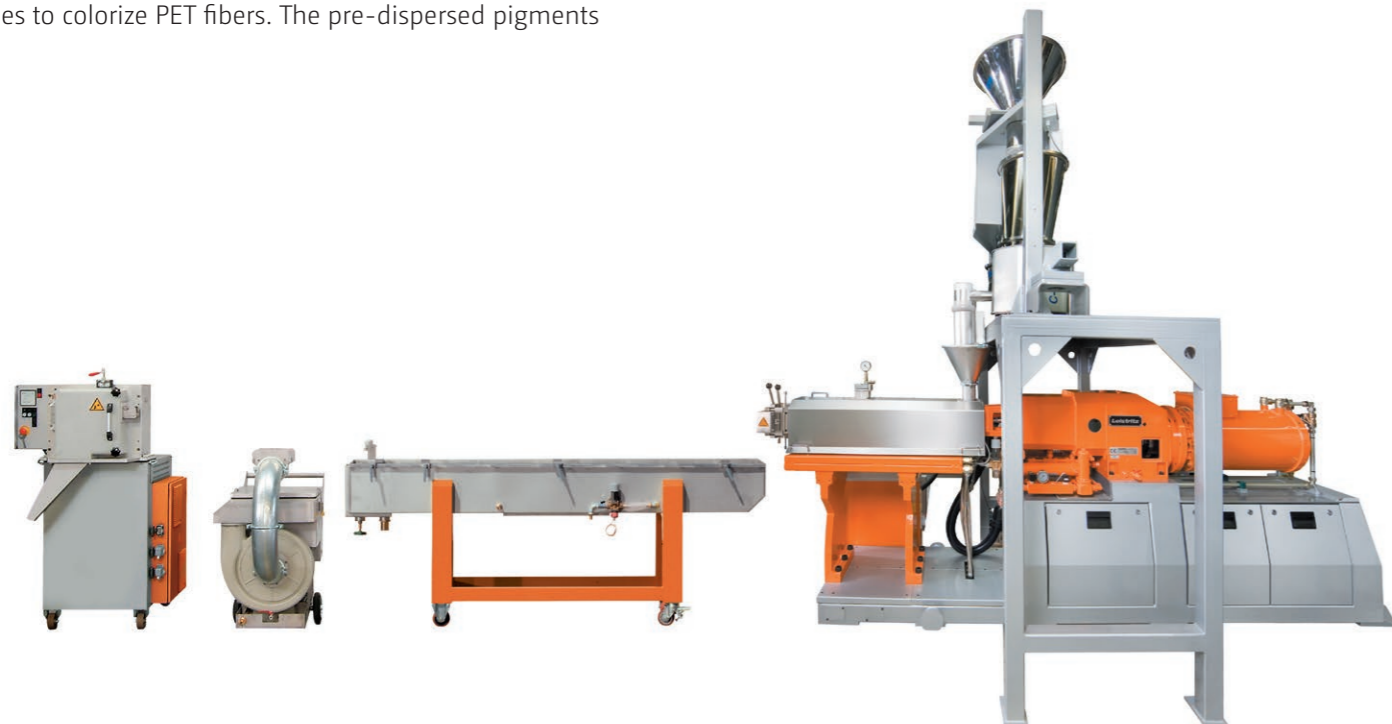
CUSTOM COLORING

The right color mix

This term describes the color adjustment by means of a mixture of various standard colors, so-called mono batches. With the help of gravimetric, multi-component feeding (usually between five and eight components), a color of the customer's choice is produced from pre-defined standard colors. The extrusion line set-up is similar to that for the premix process.

This process is also very suitable to satisfy even higher quality requirements, e.g. to produce color masterbatches to colorize PET fibers. The pre-dispersed pigments

already in the mono batch need more distributive than dispersive mixing. They can be colored more gently in a wide variety of different shades. Here again, a twin screw extruder has proven to be better than a single screw extruder.



ZSE 40 MAXX WITH CUSTOM COLORING METERING STATION

Since the extruder here is primarily responsible for mixing, a short process part is sufficient. The twin screw has the following advantages over a single screw extruder:

- better mixing effect, particularly with different viscosities
- self-cleaning, and thus advantages when changing colors
- higher product quality
- wider throughput range
- significant reduction of start-up material

AUXILIARY EQUIPMENT

For fast and optimized processes

Leistritz LSB XX side stuffer

The side stuffer is usually used to add powders. As in the extruder, co-rotating twin screws that engage with each other are used to safely feed the material into the process. The LSB XX from Leistritz convinces through:

- a high OD/ID ratio of the twin screw (easy feed of materials with a low bulk density)
- segmented screws can be used (individual adjustment depending on the process)
- the possibility of cooling the screws from the inside
- adaptation of the LSB XX to the ZSE MAXX extruder via tie rod (easy handling from behind)



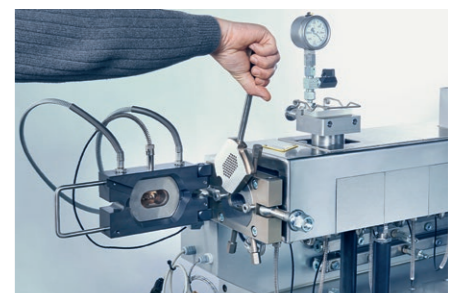
Leistritz die heads

Various die heads are available, some with an integrated screen. The focus was on the following aspects for all versions: easy handling and cleaning as well as fast access to the screws.

Example:

Leistritz strand die head with screen insert (LSA)

- specially developed Masterbatch die head: short flow channel
- ideal for small batch sizes
- fast cleaning and change of color thanks to removable screen plate
- only two bolts



Screw extraction device

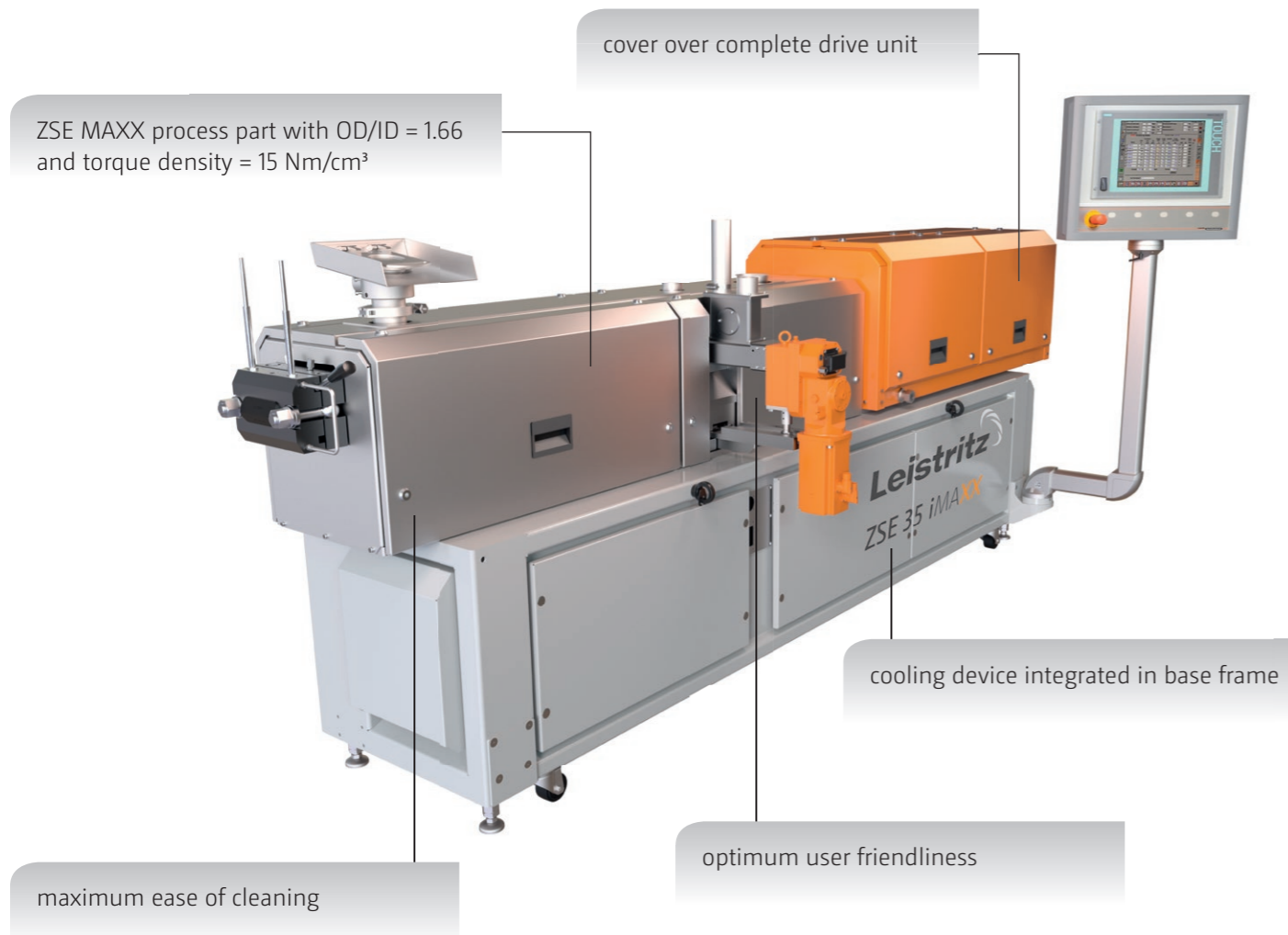
The machine often has to be reassembled for the next process quickly, particularly when producing color masterbatches with frequent, small batch sizes and a number of product changes. Leistritz thus offers a special tool to extract the screws.

- allows safe extraction of the screws
- easy handling



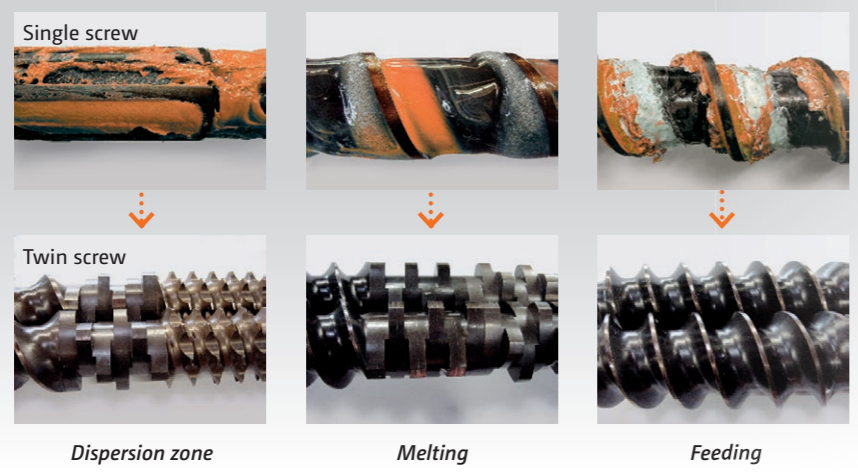
THE IDEAL MASTERBATCH EXTRUDER

ZSE 35 iMAXX - for widely varying batch sizes



maximum ease of cleaning

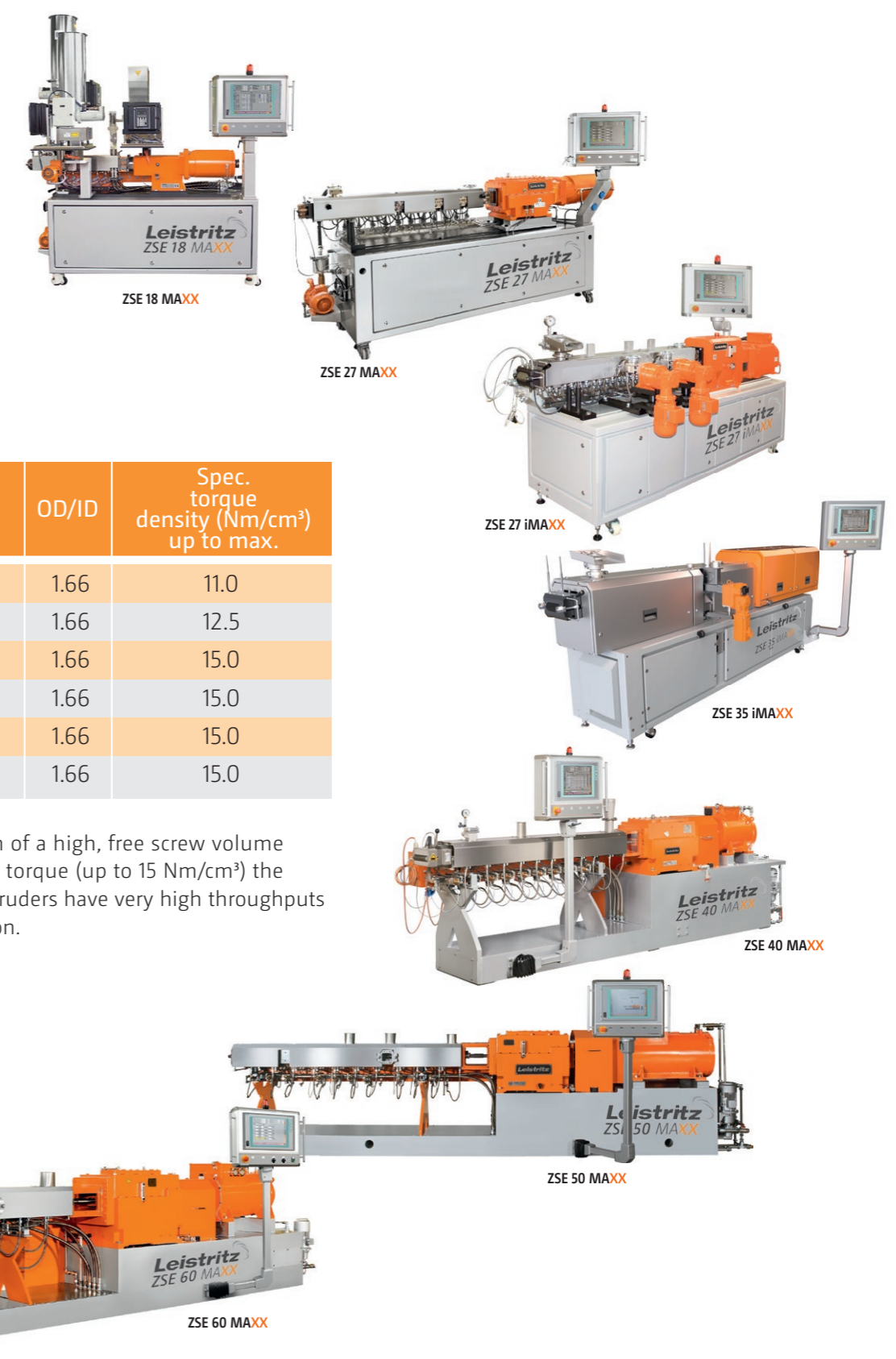
SCREW CLEANING



Since co-rotating screws wipe each other out, they have a very good self-cleaning effect compared to single screws. The photos show the difference in the feeding, melting and dispersion zone. Both extruders were only "purged" with a cleaning polymer.

ZSE MAXX SERIES

Twin screw extruders



Type	Screw diameter OD (mm)	OD/ID	Spec. torque density (Nm/cm³) up to max.
18	18.5	1.66	11.0
27	28.3	1.66	12.5
35	35.1	1.66	15.0
40	41.4	1.66	15.0
50	51.0	1.66	15.0
60	61.6	1.66	15.0

Through the combination of a high, free screw volume (OD/ID = 1.66) and a high torque (up to 15 Nm/cm³) the ZSE MAXX twin screw extruders have very high throughputs for masterbatch production.

EXTRUSION TECHNOLOGY

Available for you all over the world



➤ Leistritz Extrusionstechnik GmbH | Markgrafenstraße 36-39 | 90459 Nuremberg | Germany
Tel.: +49 911 43 06 - 0 | extruder@leistritz.com