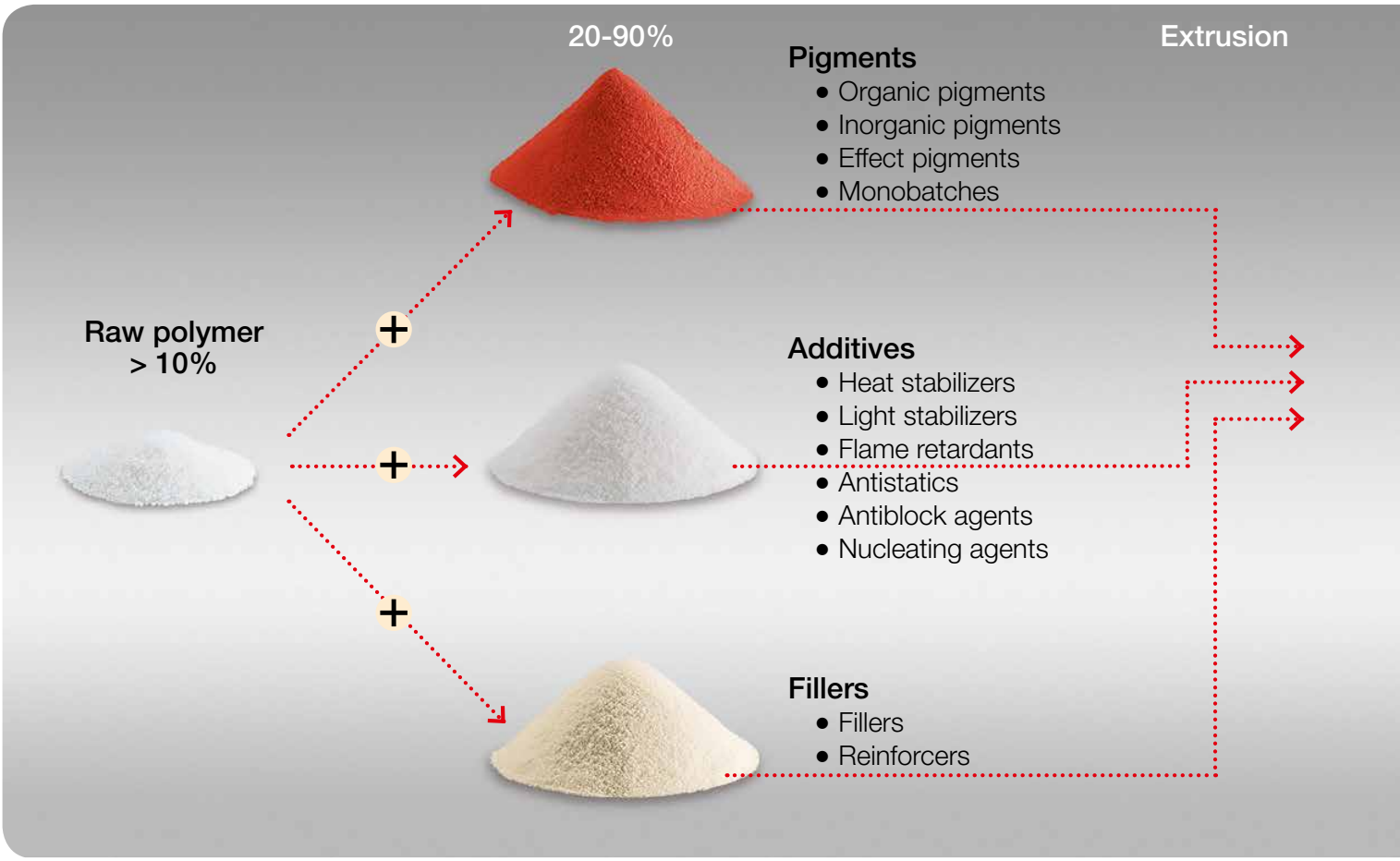
Leistritz

LEISTRITZ EXTRUSIONSTECHNIK GMBH

refreshing extrusion technology

MASTERBATCH

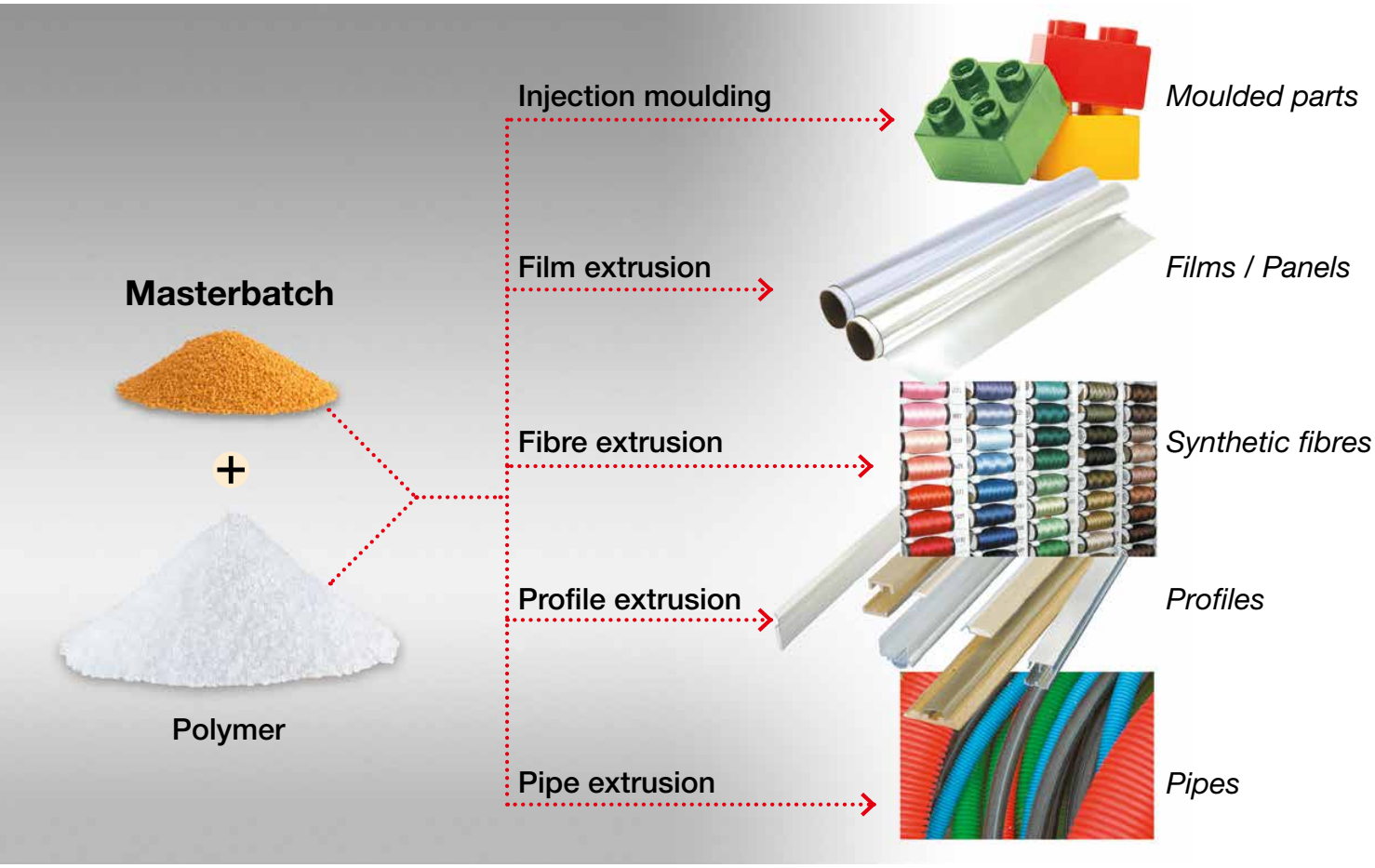
Masterbatch - Small, but with Great Effect



Masterbatch - the Grain of Difference

Polymer granulates with a high percentage of additives, higher than in the end use, are called masterbatch. In later production steps, such as injection moulding, film or fibre production, those granulates are mixed with the raw polymer for colouring or the targeted modification of certain properties.

Advantages: In comparison to pastes, powders or fluid additives, using masterbatch increases the process stability. The reason lies in the exactly defined pigment quantity in each granulate. Additionally: Since there is no handling of large powder masses and therefore the environment and the work station are not being polluted, masterbatch is regarded to be a very good processing material.



Generally, there are three masterbatch groups:

1. Colour masterbatch, which is used for colouring plastics products
2. Additive masterbatch, which provides for certain chemical and physical properties of the end product (for example UV stabilizers, flame retardants, antistatics or antiblock agents)
3. Filler masterbatch, that is filled with a high share of fillers like chalk

Pigments

	Organic pigments	Inorganic pigments		Monobatches
			Effect pigments	
Particle size	0.01 – 0.1 µm	1 – 20 µm	2 – 180 µm	very uneven: ranging from very small to large
Particle shape	isometric	isometric	step chips	depending on the pigment
Dust formation	+/-	+	n. s.	++
Dispersibility	+/-	++	n. s.	++(+)
Colour strength	++	+/-	n. s.	depending on the pigment
Resist. to shape distortion	+/-	++	n. s.	depending on the pigment
Resistance to migration	+	++	n. s.	depending on the pigment
Processibility	more dispersing energy needed, difficult to disperse	little shearing, easy to disperse, sometimes abrasive	shear sensitive - as little shear forces as possible, as high mixing effect as possible	fully dispersed, hardly any shearing needed, melted and distributed
Recommended process	premix- and split-feed* possible	premix- and split-feed* possible	split-feed*	

* see pages 6-9

Production Goal

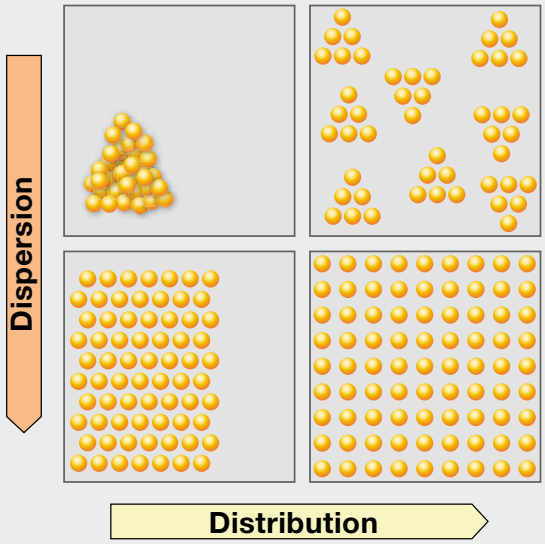
The goal of masterbatch production is the ideal dispersion of additives in the polymer matrix. The fine, powdery feed material often tends to agglomerate and therefore is difficult to work with. Masterbatches with an additive share of 20 - 90% are available, depending on the feed material.

Dispersive & Distributive Mixing

Dispersion is the incorporation of pigments, additives or fillers into a binder or carrier.
This process is divided into four steps:

1. wetting of the pigments/additives/fillers
2. splitting of the agglomerates (dispersive mixing)
3. distribution of the pigments/additives/fillers in the melt (distributive mixing)
4. stabilization against re-agglomeration

The basic function of distributive mixing is the distribution of the material without destroying the single components. Distributed particles can be elongated further in order to achieve a more even distribution of the morphological components.



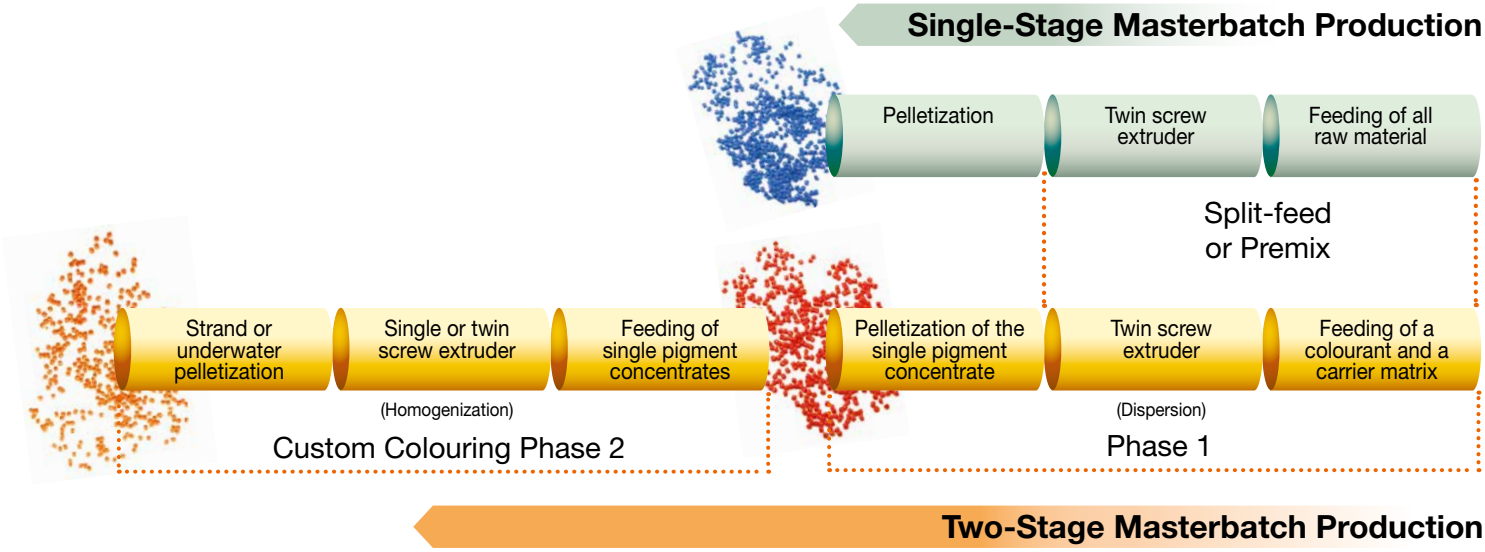
ZSE 40 MAXX - ideal for masterbatch production with throughputs of up to 500 kg/h (depending on the application)

The co-rotating twin screw extruder is the heart of a masterbatch line. High dispersion efficiency and self-cleaning are factors that are crucial for masterbatch production. The products comply with the highest demands in quality, as for example required in the production of synthetic fibres.

There are two different methods for producing masterbatch, the single-stage process and the two-stage process.

Single-Stage Process

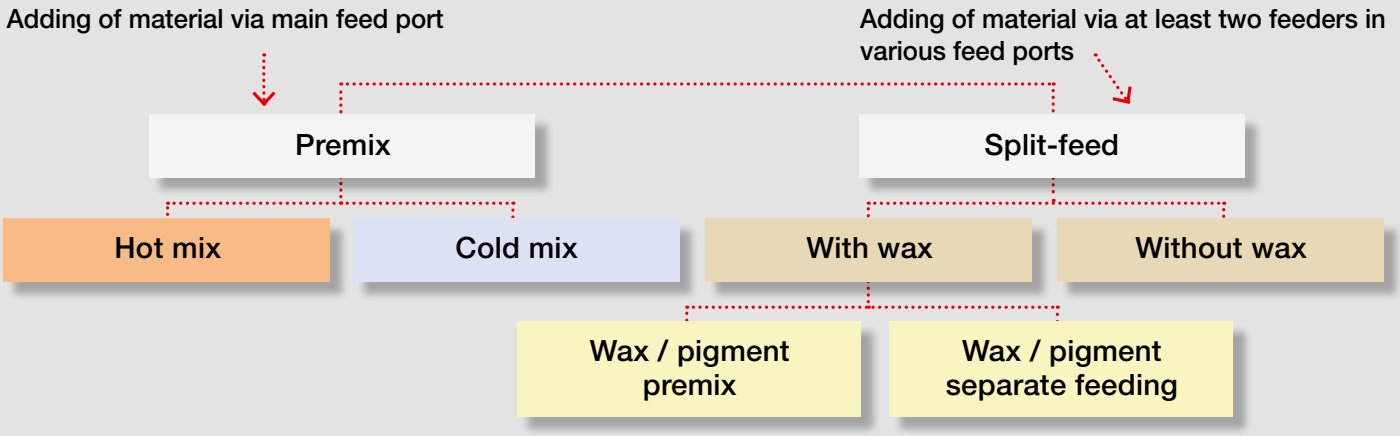
Here, all of the components in the concentrate are combined in one processing step. The process can be realized either via a premix setup (only one feeder above the main opening port) or via a split-feed setup, where each component is fed into the extruder by means of a feeder positioned above the main feed port and one or two side feeders. The single-stage process is applied for all three masterbatch groups.



Two-Stage Process

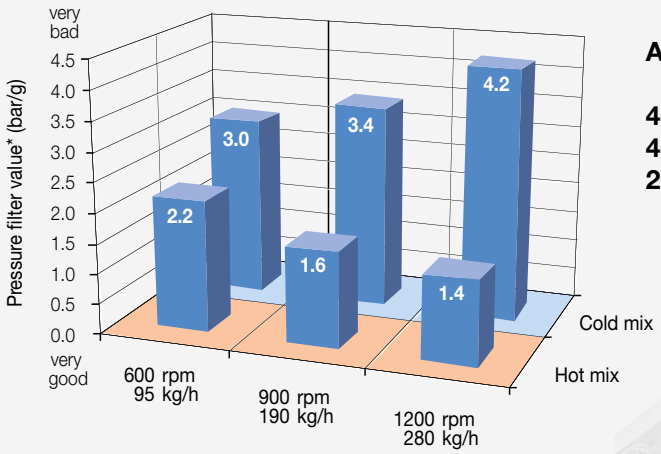
In this process, which is applied only for the production of colour masterbatch, single pigment concentrates are produced in the same manner as in the one-stage process. The first step is then followed by a second extrusion step that combines the required ratios of colourant and additive single pigment concentrate to create a masterbatch which is customized to the specifications of the customer.

Overview: Impact of Process Engineering on Colour Masterbatch Production



Example of Use

Masterbatch quality also depends on the choice of the premix process. Comparison of hot and cold mix on the basis of a certain application



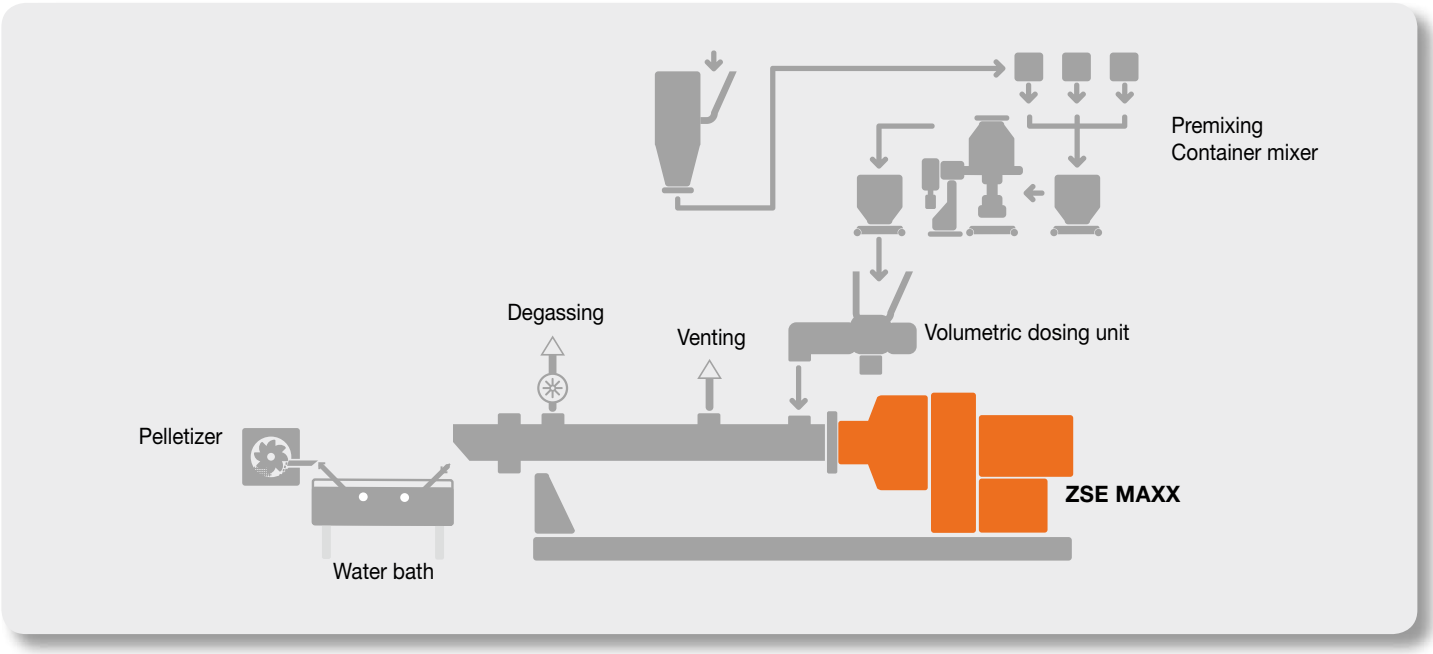
Application:

40% LLDPE powder
40% pigment blue 15:3
20% Wax

* see page 11

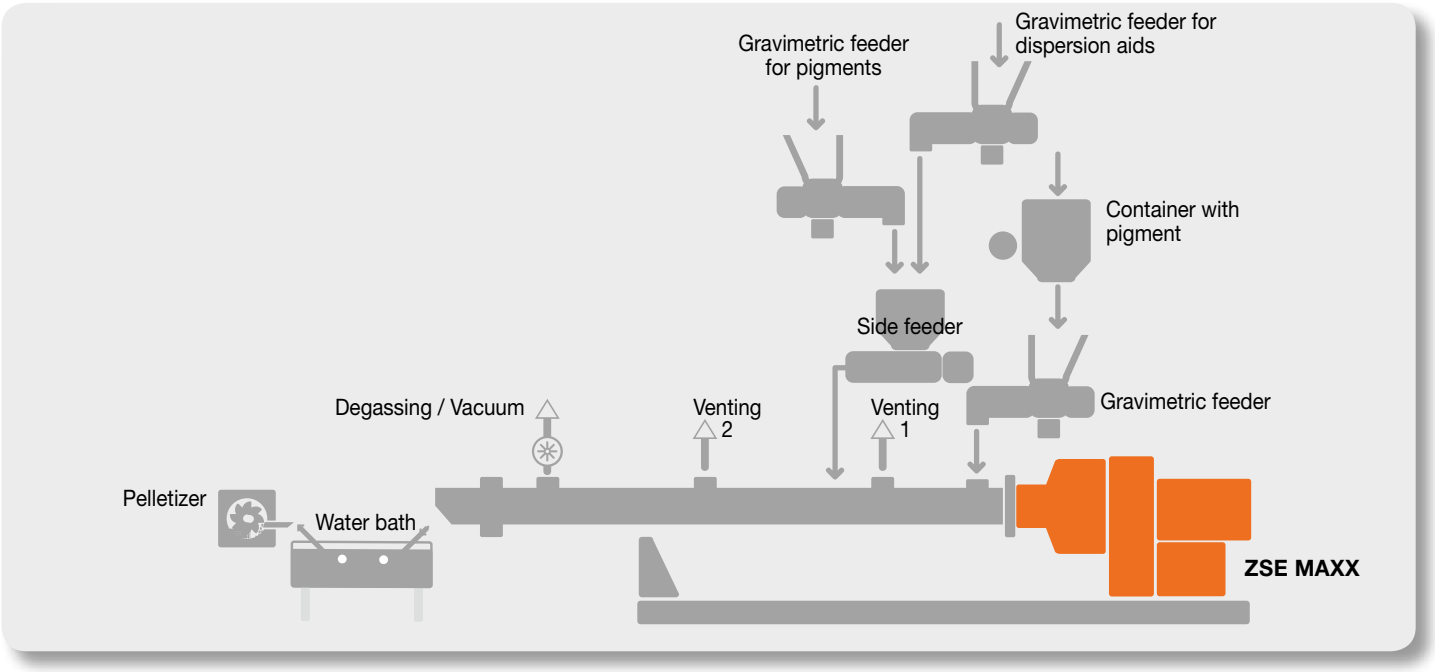
In this case, better values are achieved with the hot mix, since here the pigments are wetted with wax.

ZSE 50 MAXX line
for processing a premix



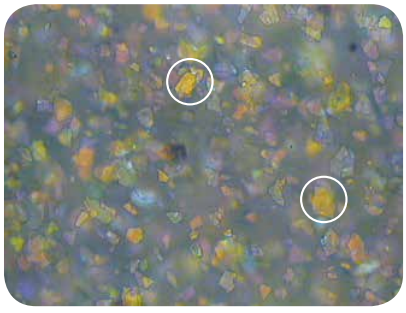
When using this, most widely spread production process, a premix consisting of polymer, pigment and dispersion additives is fed to the extruder. Normally, these premixes are produced in batches in a previous mixing step. Great importance must be given to this premix process. If a mistake happens here, unfortunately, oftentimes it is very difficult to make corrections during the extrusion step. Due to the usage of volumetric feeders, there is a high operational reliability, handling is quite uncomplicated, and the process is very popular as well as low priced.

The finished premix is fed into the extruder via a volumetric feeder. The extruder takes on the part of homogenizing and dispersion, wetting as well as distributing the pigments in the polymer matrix. In most cases a common strand granulation system is used.

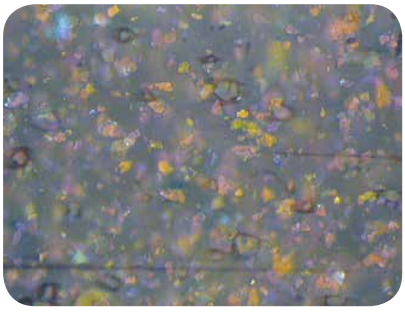


In this version of masterbatch production, the polymer is plastified first. Then the other formulation components (pigments, fillers and if needed dispersion aids) are added via one or two side stuffers (hot melt extrusion). Feeding is done via separate gravimetric feeders. The handling of the formulation via the extruder or feed control is relatively uncomplicated and does not need elaborate premixing. This makes big scale masterbatch production much easier.

Incorporation of Effect Pigments: Split-Feed is More Gentle than Premix



Split-feed, ZSE MAXX



Premix, ZSE MAXX

Mica based effect pigment in a polymer matrix: Larger particles in split-feed application ⇒ better quality.

When processing sensitive pigments (such as organic or effect pigments) split-feed is the right choice, because with this setup the pigments are incorporated into the melt more gently, and therefore experience less shearing. Split-feed must also be used when feeding a very high share of additives, since the according quantity of material cannot be fed only via the main feed port. The material stream is then divided.

ZSE 50 MAXX with split-feed

Ideal for colour sampling or low-scale production in continuous operation: **ZSE 18 MAXX**
(200 g/h - 40 kg/h) - scale-up is possible

Custom Colouring

Custom Colouring uses an exact mixture of standard colours (**monobatches**) to produce the required colour match. Via a multi-component gravimetric feed system (generally 5 to 8 components) and predefined standard colours, the colour required by the customer is produced. The setup of the extrusion line is similar to the premix system.

This process is also suitable to meet highest quality standards, e.g. for the production of colour masterbatches for colouring PET fibres. The pigments that are already predispersed in the monobatch rather need distributive than dispersive mixing. That way, they can be colourized more gently into various colour gradings. This is another example where using a twin screw extruder over a single screw has proved of value.

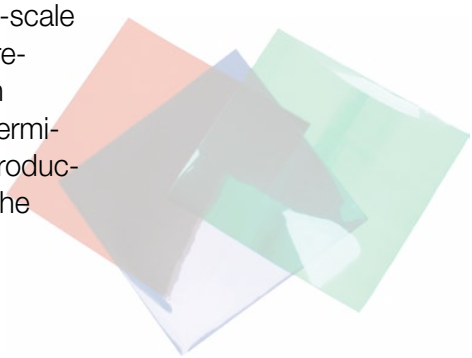
ZSE 40 MAXX with feeding station for custom colouring

Since the extruder task is mainly mixing, a short processing unit is sufficient. The twin screw has several advantages compared to using a single screw extruder in this application:

- improved mixing, especially for materials with different viscosities
- self-cleaning and consequently advantages in colour changes
- higher product quality
- wider throughput range
- considerable reduction of waste material

Assessing the quality of masterbatches can roughly be divided into three fields, depending on the final application:

- injection moulding quality: production of injection moulded sample chips for colour intensity tests and pigment distribution
- film quality: production of film on a lab-scale film blowing device to determine the frequency of uneven pigment distribution
- fibre quality: pressure filter test for determining the life times of screens in fibre production and quantity of agglomeration in the melt



The **BatchTester 20** is a testing device that combines the latest findings on standardizing the testing system with the well-proven know-how of a renown extruder supplier. As the successor of the BatchTester 30, various functional improvements were made, which guarantee precise results and make the device even more convenient to operate.

The Leistritz BatchTester 20 facilitates testing of masterbatches according to European Standard EN 13900-5.

Technical Data

design	single screw
screw diameter	19.9 mm
material of the screw	VSA1
barrel diameter	20 mm
barrel material	VSA1
screw length	25 D
drive capacity	2.6 kW
screw speed	max. 110 rpm
extrusion height	1,110 mm
weight	approx. 300 kg

Pressure Filter Test

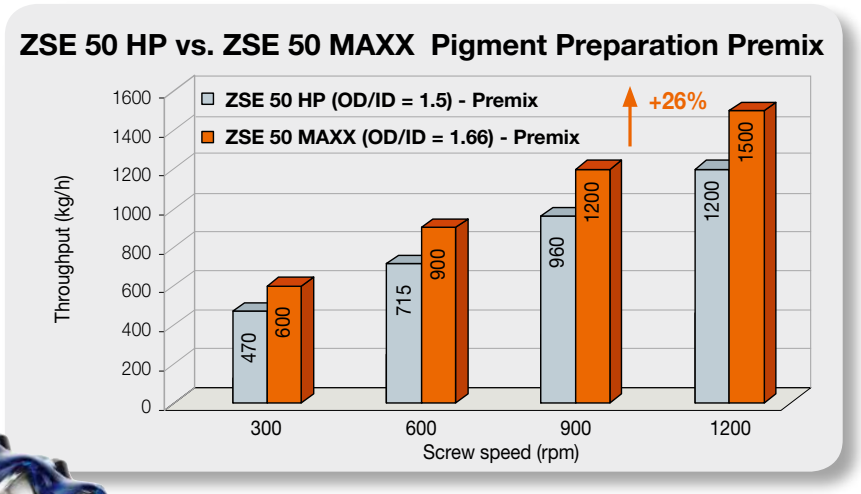
When conducting a pressure filter test, a polymer/pigment premix is melted in a single screw extruder and discharged via a melt pump. The melt is pressed through a defined screen with a defined screening surface and a predetermined aperture size. In the course of measurement, the screen is more and more blocked by spots and agglomerates. This causes a certain increase of pressure. The pressure increase is part of a formula which determines the so-called pressure filter value.

higher pressure filter value = worse product quality

lower pressure filter value = better product quality

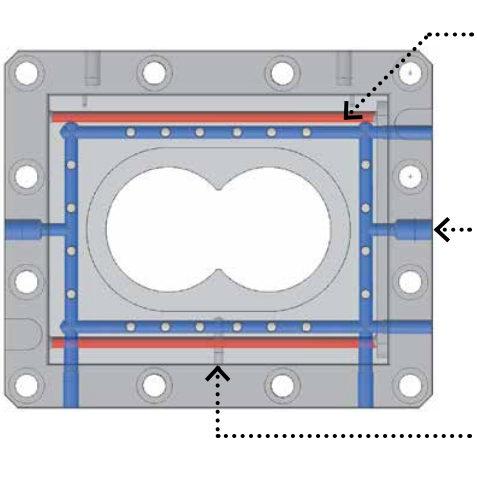
The ZSE MAXX series offers convincing advantages, especially for masterbatch production. By combining high torque (up to 15 Nm/cm³) and higher free screw volume (OD/ID = 1.66) the following enhancement is obtained:

This example of a typical volume restricted masterbatch premix application shows a considerable increase of throughput.



Heating/Cooling of the Processing Unit

Extremely precise heating and cooling of the processing unit is a crucial factor for product quality in masterbatch production. Organic and inorganic pigments as well as additives oftentimes can only be incorporated within a limited temperature range. The optimum combination of cooling and heating in the control loop of the temperature device is a significant quality feature of the extruder. Thereby, each barrel is a separate heating/cooling zone.



Barrel Heating/Barrel Cooling

In order to heat up the barrel in a fast and effective way, heating cartridges are used. They enable:

- quick warm up
- quick melting and wetting
- energy saving ⇒ heating inside the barrel in contrast to heating bands or angular heaters (see figure on the left)
- efficient spare part administration ⇒ same type of heating cartridges for all barrels of one extruder type

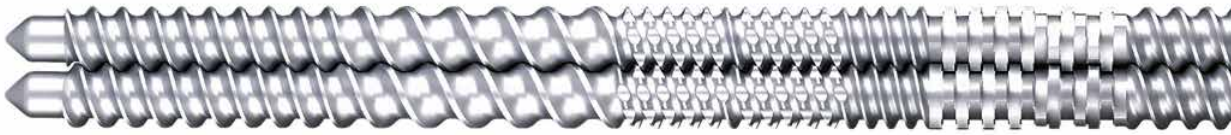
Naturally, an increase of throughput makes a more effective barrel cooling necessary. Leistritz is the first extruder supplier, who introduced the so-called maXXcooling, a sophisticated, self developed cooling method, which increases the flow of the cooling agent and works with the counter flow principle. By placing the cooling bores close to the screw channel, a more intensive barrel cooling is obtained.

Layout of Screw Geometry

The extruder screws are designed as modular systems. The screw elements are slid onto the shaft in the desired configuration. The unique splined screw shaft design - maXXshaft - realizes a higher torque transmission than in standard extruders.

Generally, there are conveying, kneading and mixing elements. Hundreds of different screw elements can be combined.

Co-Rotating Compact Screw



As soon as the ideal geometry for the main application is found, Leistritz offers a custom made compact co-rotating screw set. Since there are no junctions between the screw elements, the compact screws are especially suited for applications with frequent colour changes. Furthermore, the costs for a screw set can be reduced by up to 40%!

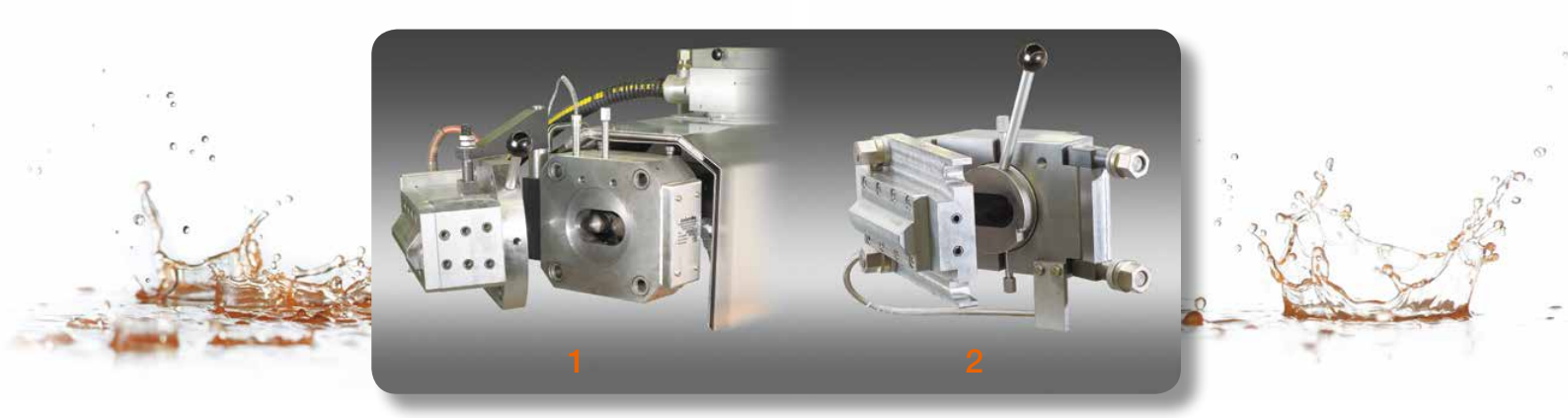
Cleaning of Screws

In comparison to a single screw, the self-wiping capability of a twin screw is quite impressive. The pictures show the difference in the feeding, melting and dispersion zone. Both extruders were only purged with a purging polymer.

Reduced Cleaning Times

Leistritz extruders are designed and built to minimize downtimes. They have to be able to be reconfigured very quickly for the next process, especially, when producing colour masterbatch with small batch sizes and frequent colour changes.

Time can be saved in various places:
Leistritz offers several die heads - partly with integrated filtration. Here, special attention was paid to easy handling.

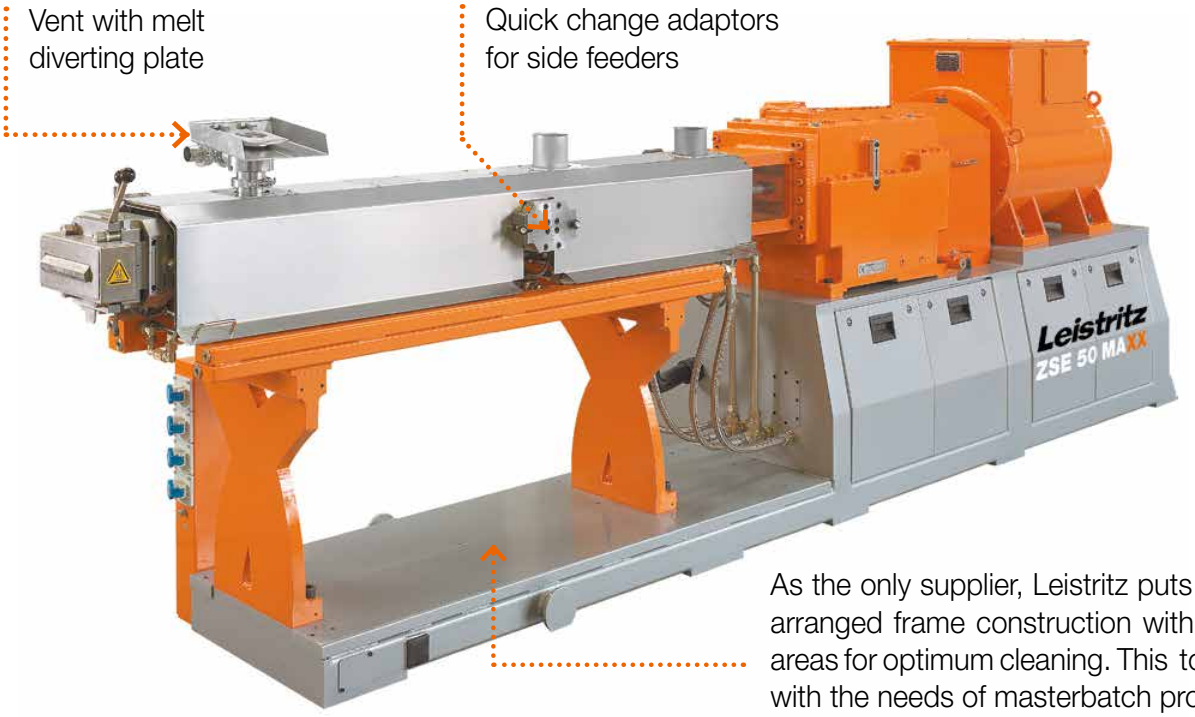


1 Leistritz strand die head - pivoted, (LSSK), specially designed masterbatch die head. Advantages: cheaper and bigger production batches possible

2 Leistritz strand die head (LSA). Advantages: quick cleaning and colour change

Leistritz die heads convince by a special masterbatch die plate for quick cleaning.

Time can also be saved by means of:



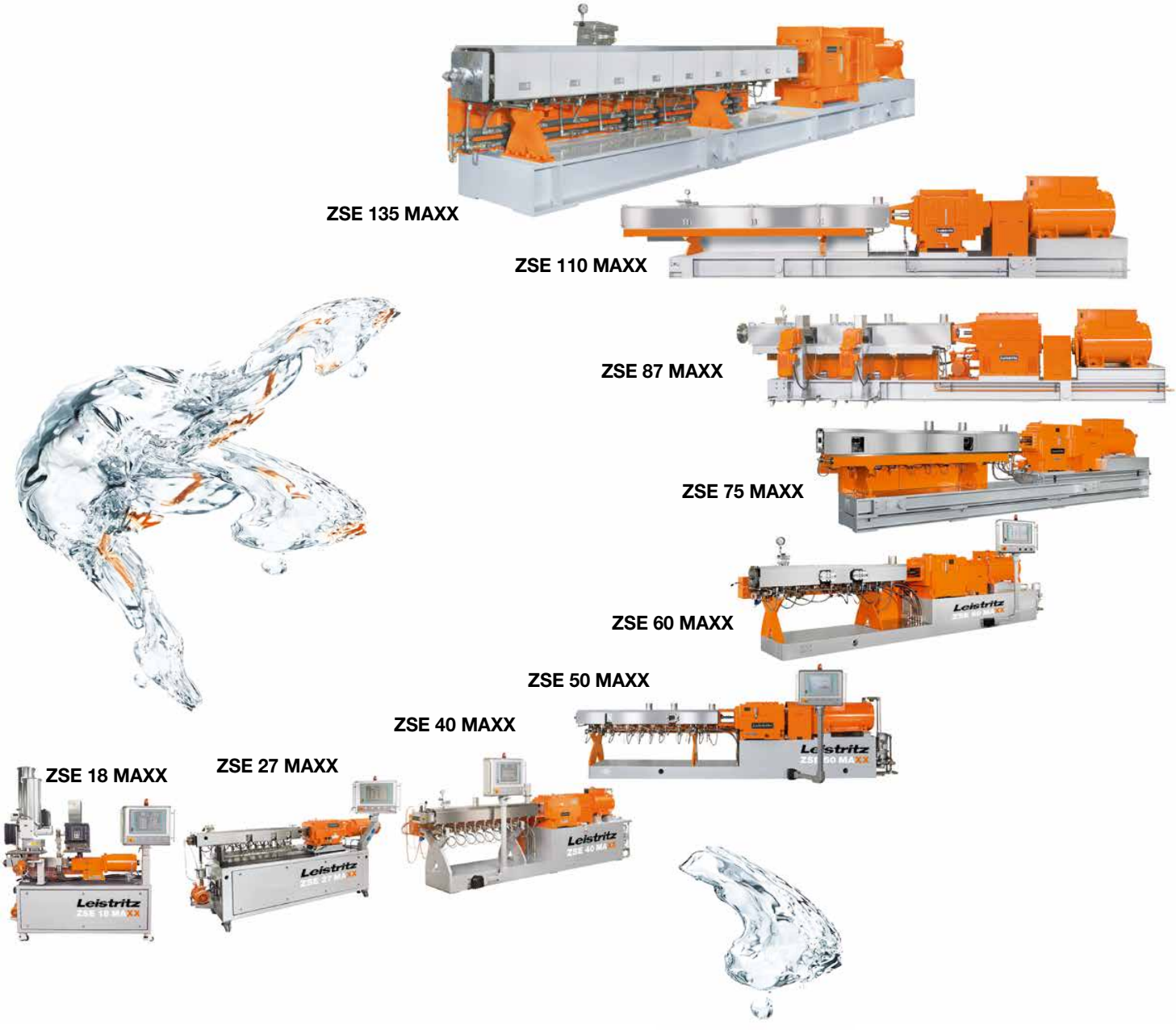
As the only supplier, Leistritz puts a focus on a well arranged frame construction with easily accessible areas for optimum cleaning. This totally corresponds with the needs of masterbatch producers.

Formulation development is done on twin screw extruders with relatively small screw diameter. These laboratory results are later transferred to larger production lines (Scale-up).

It needs to be considered, that scale-up factors up to 10 are common practice. This means: If on a laboratory machine with a throughput of 15 kg/h good results are achieved, these results can be transferred to a production line with a throughput of 150 kg/h.

However, a prerequisite for reasonable scale-up is the geometrical similarity of the machines. Geometrical basic parameters of the laboratory machine like shear rate, shear stress, residence time, specific drive power and the ratio of outer and inner diameter of the screw element should correspond with the production machine.

Scale-up - the key skill of the Leistritz ZSE MAXX series!



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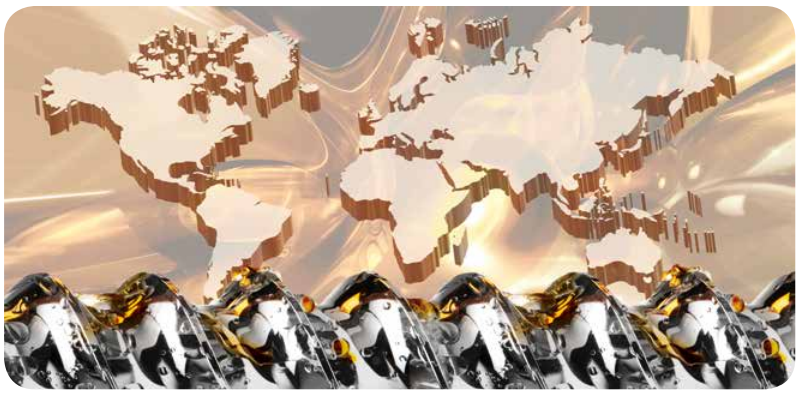

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