

COLLIN TECHNEWS

COLLIN - TECHNOLOGY MAGAZINE

COMPOUNDING

black magic,
alchemy
or exact
science?

EDITORIAL

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Dear Readers!

Just nowadays, we are experiencing that there is a change in plastic industry. Plastic generates negative headlines again and again – from micro plastic up to plastic islands in the sea. Therefore, the topic recycling becomes even more important and a burning issue – in R&D, for mechanical engineering companies or for the plastic processing industry.

In order to facilitate the recycling of polymers, the material has to be more homogenous and compatible. This, in turn, offers for companies for example the option to refeed the pellets, recycled via inhouse recycling, into the production

process – and thus the own energy footprint can be improved.

Here, compounding is often the technology of choice. Additives and fillers are incorporated into the plastic mass in order to create new characteristics. For this purpose, COLLIN offers solutions for simple to highly complex applications, which can directly be integrated into blown or cast lines. Instead of an extruder, a compounder is used, which degases the plastic and mix it with different additives. Among other things, compounding is suitable for packaging and technical or medical products.

For customers of the NGA Group, it is an advantage that the group covers the complete life cycle up to recycling: NGA does analysis and simulation, COLLIN is international pioneer in the field of compounding technology resp. product development and BritAS bolt screen changers are the perfect solution for the processing of plastic waste to pellets. Read more in the TECHNEWS 3.

Friedrich Kastner

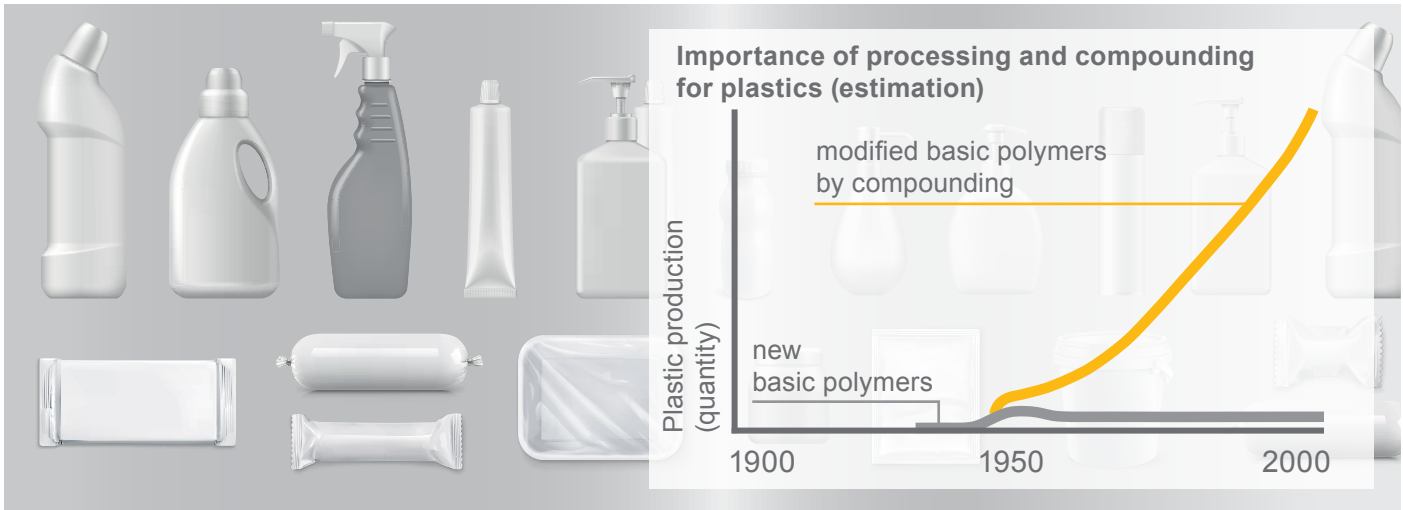
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3.1

COMPOUNDING – BLACK MAGIC, ALCHEMY OR EXACT SCIENCE?

Systems engineering for development and small batch production

Author: Dr.-Ing. Franz Grajewski

The term compounding is deduced from the Italian word „componere“, which means „put together“. With it, the most important process in the processing of plastic is perfectly described, because all characteristics of the end product are defined. Generally, such a mixture consists of:

- ▶ Basic polymers
- ▶ Fillers
- ▶ Additives

For pharmaceutical applications, API (active pharmaceutical ingredient) is also added.

The following additives and fillers are often used:

- ▶ Antioxidants
- ▶ Lubricants
- ▶ Impact modifiers
- ▶ Antistatic
- ▶ Carbon / glass fibres
- ▶ Chalk
- ▶ Talcum
- ▶ Barium sulphate
- ▶ UV and heat stabilizers
- ▶ Demoulding aid
- ▶ Fire protection agent
- ▶ Carbon black

The following graphic 3.1 shows the importance of compounding for the development of more and more specialized plastic products (according to /1/)

The image shows, that mainly in the fifties and sixties, a variety of different basic polymers was developed. The enormous variety of characteristics of plastic products is exclusively based on compounding.

In the beginning years of plastic production and development, only discontinuous procedures (batch procedures) were used. Nowadays, these are still common in the rubber industry.

■

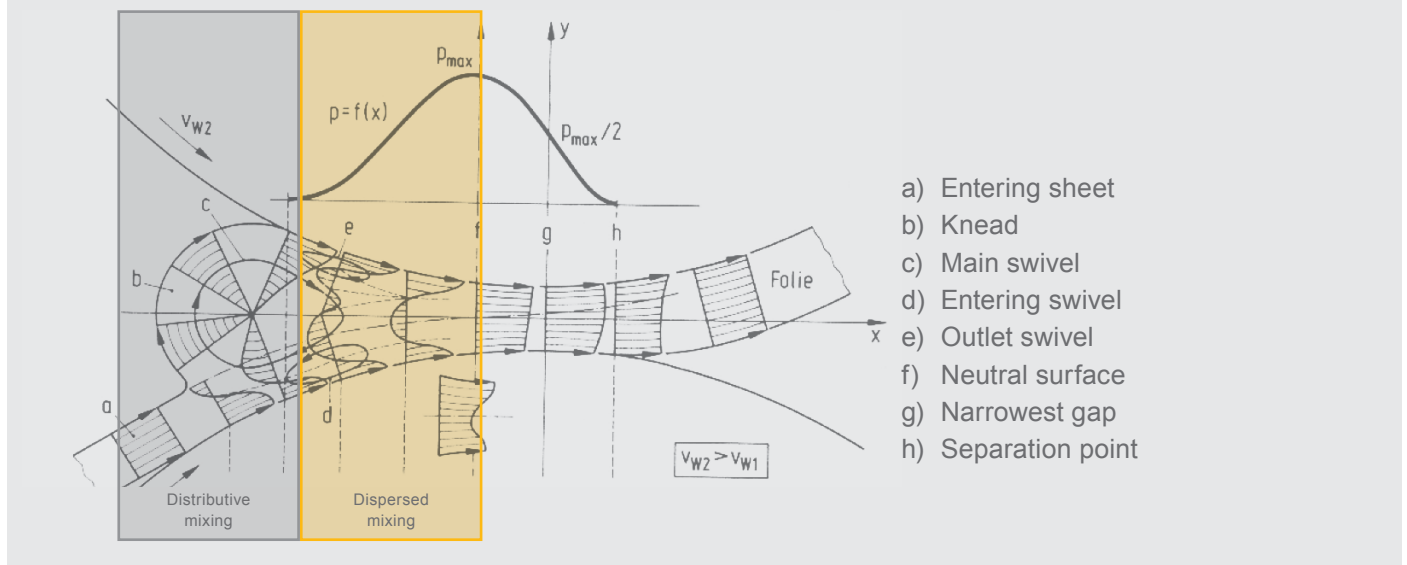
Mixing with roll mills

The most important batch processing procedure is the mixing with roll mills. Typical applications are

- ▶ Incoming goods inspection for raw materials
- ▶ Recipe development for calenders
- ▶ Checking the influence of additives on the processability of PVC, PO, PET, etc.
- ▶ Development of processing aids
- ▶ Colour development for calenders and in the production of pigments and masterbatches
- ▶ Development of elastomer mixtures

The complex flow processes in a roll gap are shown in image 4.1.

Flow processes and mixing types in the roll gap (according to /2/)



4.1

The flow areas are influenced by the pressure build up in the roll gap (curve shown schematically). The maximum is shortly before the narrowest position in the gap and defines the ratio drag volume flow (into the gap) and pressure volume flow (opposite). As a result, the knead is formed with the main swivel, which is characterized by its distributive mixing effect. In the following area up to the pressure maximum, dispersed mixing takes place, because here, the shear stresses have the highest value.

The pressure curve is characterized by:

- ▶ Roll gap geometry
- ▶ Circumferential speed of the rolls
- ▶ Viscoelastic characteristics of the mixture
- ▶ Surface temperature of the rolls
- ▶ Residence time in the roll mill

Thus, the first precondition for reproducible mixing results is a mechanically running high-precision roll mill, which guarantees an exact control of the roll surface temperatures. Machines for this application have to fulfil the following requirements:

- ▶ Massive, highly precise base frame
- ▶ Hard-chrome plated, polished rolls with highest true running accuracy (2µm)
- ▶ Controlled gap width right and left (+/- 0.01mm)
- ▶ Gap width measurement directly next to the roller end
- ▶ Total bearing force up to 100kN
- ▶ Bearing clearance compensation by hydraulic pretension
- ▶ High speed constancy with control range 1:50
- ▶ Peripherally bored rolls generate a temperature accuracy of +/- 1K »

Since its foundation in 1972, COLLIN Lab & Pilot Solutions has been developing and manufacturing roll mills for laboratory applications. The so-called measuring roll mills have quickly become established on the market and in the beginning, they were mainly used for the PVC recipe development.

Image 5.1 shows a fully equipped W 150 M. With a roll diameter of 150 mm and a roller width of 400 mm, this size is ideal for all kind of development applications.

Image 3: Measuring Roll Mill W 150 M

For an independent operation, these machines are equipped with different automation devices. These devices are shown in image 5.2.

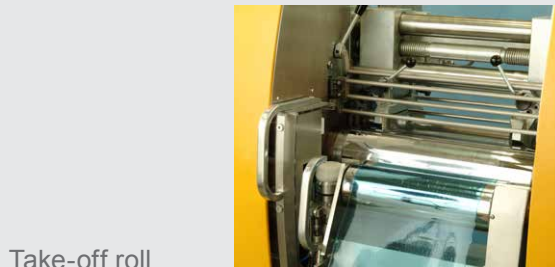


5.1

Automation devices of the measuring roll mill



Heavy reversing roll



Take-off roll

5.2

Besides the bearing force measurement and roll torque measurement, there are additional measuring devices, which can be seen in image 5.3.

Measuring devices at the roll mill



Knead height measurement
with laser beam

Knead temperature sensor

Reversing device for adhesive
force measurement

Reversing support
for thin, soft and hard
materials

The reversing device is not only used for the determination of the adhesive force of the mixture on the roll surface but also improves the homogeneity by a cross mixing effect, similar to a stock blender at a rubber roll mill. »

5.3

For the processing of smaller batch weights, there are swivelling and axially movable sealing jaws for any working width (see image 6.1).

Process-related, a roll mill runs with openly accessible parts, which form a dangerous feed gap. Therefore, roll mills from COLLIN Lab & Pilot Solutions are equipped with comprehensive safety devices (see image 6.1).

Safety rockers prevent reach into the gap. In case of an emergency stop, an automatic quick stop and a hydraulic opening of the gap to 80 mm are released.

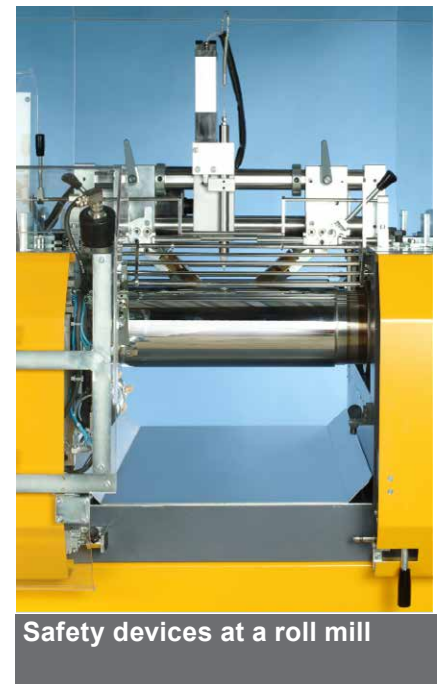
For machine safety, there is a hydraulic overload protection and a digitally adjustable minimum gap limit. Furthermore, there is a minimum gap protection by feeler gauges, which, in case of an abrupt closing of the gap (e.g. in case of a sheet breakage), are pulled in and thus, the safety switch-off is activated.

As with all lines from COLLIN Lab & Pilot Solutions, also the roll mills are equipped with a sophisticated control and data logging software. Also this software serves to run the process independently from the operator as far as possible. The requirements for a modern roll mill control can be summarised as follows:

- ▶ Control of all machine functions
- ▶ Ergonomic operation panel and graphic
- ▶ Clear display of all parameters as actual and set value
- ▶ Control of the time flow of the measuring programs
- ▶ Storage of the measuring programs as recipes
- ▶ Automatic starting of stored rolling programs
- ▶ Recording and logging of all measuring values
- ▶ Graphic representation of all values for evaluation
- ▶ Network connection

Of course, in the laboratory sector, there is a number of applications, for which the variety of possibilities of a measuring roll mill is not required and the use is not justified from an economic point of view. The so-called testing roll mill, as exemplarily shown in image 6.2, is a type which is often delivered.

It is immediately recognizable that only the essential functions of a roll mill are available. However, it must be stressed that the precision of the machine regarding mechanics and temperature control is the same. An overview of further roll mills from COLLIN Lab & Pilot Solutions can be seen below: »



6.1



6.2

Table-top roll mills

- ▶ Roll diameter 100, working width 150
- ▶ Testing of small batches in research and development

Simple testing roll mills

- ▶ Roll diameter 110 & 150, working width 265 & 315
- ▶ Routine checks at material producers, processing companies, compounding companies, masterbatch producers and pigment producers

Automatic testing roll mills

- ▶ Roll diameter 110 & 150, working width 265 & 315
- ▶ Automatic routine checks with high reproducibility at considerably reduced personnel placement

Rubber roll mills

- ▶ Reinforced drives, gears and additional equipment, vapour or water tempering ■

Continuous processing in the extruder

Although the batchwise processing as in the processing of rubber or as shown above in material development is absolutely justified, these processes have one essential disadvantage. The discontinuous operation results in starting effects, which, within a batch or also from batch to batch, have quality differences regarding the homogeneity of the mixtures.

Certain continuous mixing tasks can be realised with a single-screw extruder. However, the mixing effect of a pure conveying screw is very restricted. Furthermore, in a single-screw extruder, the variety of possible mixing components cannot be dosed. The common mixing task in the single-screw is incorporating and homogenizing colour pigments. For that purpose, normally, at the end of the screw, mixing elements are arranged. Over the decades, a huge variety of mixing element geometries has been developed. Which geometry is the best, is rather a philosophical question and cannot be concretely be answered. COLLIN Lab & Pilot Solutions single-screws

have screwed mixing elements, which is especially of importance during test operation. The geometry suitable for the mixing task can thus quickly be determined. An additional homogeneity improvement is achieved with static mixers, which are mounted between extruder end and tool. It has to be observed that nearly all mixing elements and the static mixers are pressure consumers.

With the invention of the co-rotating twin-screw extruder /3/, continuous mixing developed itself as the most important processing method for plastic. The success of the method is based on the constant quality and homogeneity of the produced material. »



Besides the processing and incorporation of fillers, these machines are also used for reactive extrusion.

By combining different polymers and / or fillers, fibres etc., the following characteristics are adjusted very purposefully:

- ▶ Strength, flexibility etc.
- ▶ Chemical resistance
- ▶ UV resistance
- ▶ Sliding behaviour
- ▶ Abrasion resistance
- ▶ Magnetic characteristics
- ▶ Electric conductivity
- ▶ Thermal conductivity

In the course of the CO₂ reduction, enormous efforts are being made to reduce the weight of vehicles and to develop batteries. For example, in a research cooperation at the SKZ, it is being investigated how the electric conductivity of components with simultaneous wall thickness reduction can be improved /4/.

In /5/, new magnetic materials with high thermal conductivity for the heat management in batteries but also for the use in electric motors (weight reduction) are described.

The so-called nanocomposites are an increasingly important group of substances. Nanoparticles with a size of approx. 5 nm to approx. 100 nm are incorporated into a polymer matrix /6/. These „midgets“ significantly influence the optical, electrical, mechanical, biomedical and thermal characteristics of the matrix material. Typical mass fractions are between 0.5% and 5% /7/. Essentially, their high effectivity is based on their enormous specific surface and / or on their aspect ratio. Large specific surface, combined with corresponding surface tensions, however, are a disadvantage for the processing, because they tend to form agglomerates, which for example in the compounder requires special screw designs /8/. ■

THE MIXING PROCESS

In principle, there are two types of mixing processes in the processing of plastic:

- ▶ Mixing in the solid phase
- ▶ Viscous mixing

Mixing in the solid phase

Mixing in the solid phase is used if the number of additives exceeds the number of possible dosing stations at the compounder. This is what is known as pre-mixtures. It is pure distributive mixing. The aim is to achieve a homogenous distribution of all particles. There is a variety of different mixing aggregates, but here, it cannot be described in detail. They differ in size and shape of the mixing container, the stirrer geometry, stirrer speed, temperatures etc. If liquid components are added, heating

/ cooling mixers are often used to manage the diffusion into the pellets at moderate temperatures. These mixers are often used in the dry blend production of PVC. The production of pre-mixtures is made batchwise. It has especially to be observed that the density differences of the individual components are not too large, since otherwise for example this can result in a de-mixing in the dosing hopper.

Viscous mixing

Generally, the viscous mixing consists of six areas:

- ▶ Melting polymers
- ▶ Melting other solids (e. g. wax)
- ▶ Incorporating all components into the melt
- ▶ Crushing agglomerates
- ▶ Separating all undesired components (humidity, low-molecular components)
- ▶ Homogenizing

These process steps have to be part of the machine and influence the cylinder and screw geometry.

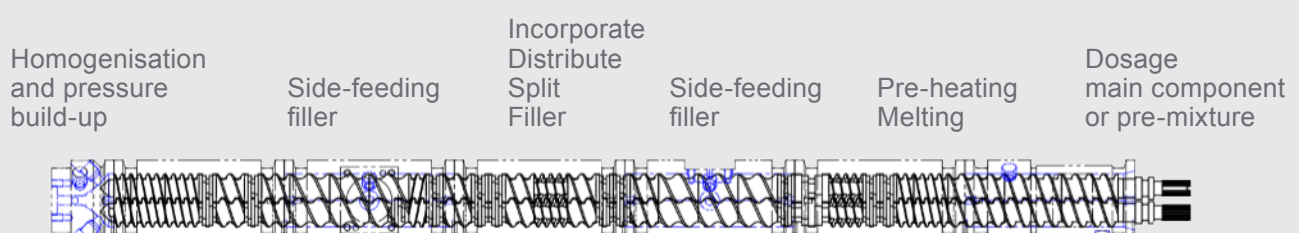
With the variety of mixing tasks in the twin-screw extruder, it is obvious that a geometry, that has only once been fixed, is surely not enough. In the 1950s, this resulted

in the invention of the modular design of the processing units /9/. This design offers enormous advantages /10/

- ▶ Procedurally different zones are defined along the machine
- ▶ High flexibility regarding geometric variants in test operation and production
- ▶ Economical adaptation to future process adaptations and modifications
- ▶ Standardisation of the different screw elements
- ▶ Cost-effective storage

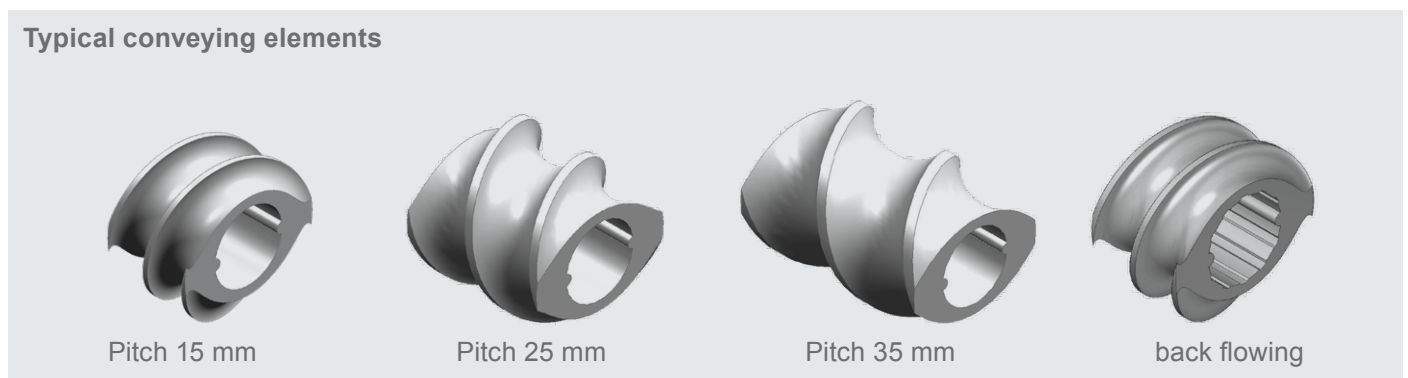
A typical screw configuration, which is often used in the technical centre at COLLIN Lab & Pilot Solutions, is shown in image 9.1. »

Typical twin-screw geometry with process sections



In this case, the screw diameter is 25 mm, the length of the processing unit is 48D and has a main dosage and a side dosage. For filler contents of up to approx. 40%, this is quite sufficient. For higher filler contents, at least two or even three side dosages are necessary. This results in the fact that the processing unit becomes longer in order to have the necessary length (residual time) for the incorporation and dispersion.

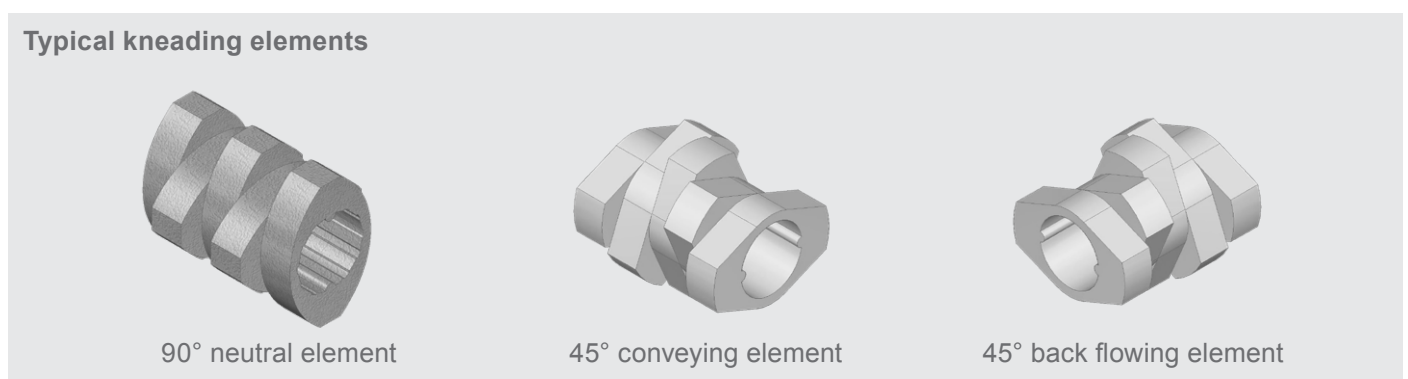
The most important screw elements are conveying elements and kneading elements. Image 9 shows typical conveying elements for a screw diameter of 25 mm. They differ in their pitch. By a pitch extension, the free volume in the corresponding screw section is extended. Thus, the arrangement of conveying elements with decreasing pitch results in a compression of the material. Normally, this is used in the processing area heating up and melting of the polymer components. In the areas where fillers or liquids are dosed, a large, free volume is required. Thus, a large pitch will be used.



10.1

On the one hand, back flow elements increase the mixing effect, on the other hand, they are used for separating the degassing zone.

Kneading elements bring stretching deformations and high shear into the material. Thus, they support the melting process by dissipative energy input and of course, they generate an excellent mixing effect. In image 10, commonly used designs can be seen.



10.2

These elements are geometrically characterized by the number of discs, the offset angle and the disc thickness. A pitch is not defined. Conveying, back flowing and neutral elements are distinguished. The neutral elements act like pressure consumers and must be crossed over by the previously conveying zone. »

The so-called mixing elements are a third class of screw elements. In order to divide the material flow additionally, the screw flights must be broken at certain distances (by grooves). Image 11 shows a design example.

The geometry is defined by diameter, pitch, number of breaker grooves and their dimensions. It is easy to imagine that in such zones, there are very complex flow processes.

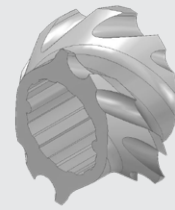
When considering such geometric conditions (image 8), it is easy to see that a complete theoretical description of the process is not possible. However, for segments of the screw zones, there are interesting approaches, in order to make the processes mathematically accessible. /10/ provides an overview. At this point, this subject won't be discussed in detail.

Of course, the screws must be driven. The throughput of a co-rotating machine is defined by the torque. This is defined by the solidity of the screw shaft and by the geometry of the positive locking between shaft and screw elements (involute gearings, splined shaft). The shaft surfaces are often especially hardened. The screw geometry (distance between axles, diameter, radial and axial screw clearance) results from the procedural task.

The relatively small distance between the axle, the high screw speed and the desired torque place very high demands on the gears. Additionally, there are the axial loads due to the pressure build-up in the screw, which have to be absorbed via so-called back pressure bearings. In the gear, the narrow screw plays only allow very small, elastic torsion and axial deformations. Special tooth geometries and surface treatments fulfil these strict requirements. As design size independent measure or the torque density of a gear, the so-called torque factor is defined. This is formed by the torque related to the cube of the distance between the axle.

The most important procedural parameter of the process is the specific energy introduced into the mixture via the screws. It is characteristic for each product and applies regardless of the extruder size /10/. Thus, it is the most important criterion for the scale up of a process. ■

Example of a mixing element ø 25 mm



11.1

$$e_s = 2\pi n M_d / \dot{m}$$

- ▶ e_s : specific energy
- ▶ n : screw speed
- ▶ M_d : torque at the screws
- ▶ $\dot{m}$: throughput

The unit is kWh/kg.

THE COMPOUNDING TECHNOLOGY OF COLLIN LAB & PILOT SOLUTIONS

The development of the COLLIN Lab & Pilot Solutions roll mills resulted in an intensive examination of the mixing process of plastic. It was a logical result to use this know-how for the development of the continuous processing. Already in 1981, the first co-rotating machine was placed on the market by COLLIN Lab & Pilot Solutions. It was a ZK50, a twin-screw kneader with a maximum processing length of 12D and designed with one-piece screws. The maximum speed of 90min^{-1} was rather modest. Approximately 10 years later, the features of a compounder could be recognized. The screws and cylinders were modular, processing length up to 18D and speeds up to 250min^{-1} were possible: The maximum operating temperature was 350°C . In the following years, the following types were designed :

- ▶ Teach Line Compounder 12mm, 16mm und 25mm
- ▶ The ZK P(rofessional) series with screw diameter 25mm and 35mm
- ▶ The ZK E(ntrance) series with screw diameter 16mm, 25mm

In a generously furnished technical centre, COLLIN Lab & Pilot Solutions provides a considerable number of machines and lines, among others a ZK25P and various

Teach Line compounders. These are operated by an experienced team. Thus, COLLIN Lab & Pilot Solutions offers comprehensive possibilities to carry out material examinations and process tests with different screw geometries prior to or at the beginning of a project. Mostly, important knowledge for the design of a compounding line is gained. Especially for new developments, this is essential. Of course, the technical centre can also be used for paid customer tests, regardless of whether this results in a project.

In 2009, COLLIN Lab & Pilot Solutions introduced a quality management system, which controls the processes for the manufacture of its products. In this context, the important instruments are:

- ▶ Design Reviews (at a certain design progress also the customer)
- ▶ Error possibilities influence analysis (FMEA)
- ▶ Risk analysis

This ensures that the machines and lines meet the customer requirements and all state-of-the-art safety rules. ■

ZK P Compounder

The P series Compounders (ZK25P, ZK35P) convince by their high torque density, which allows the processing of all highly viscous and highly filled polymers. The machines run with a maximum speed of 1200min^{-1} .

Depending on the mixing task (number of polymers, additives, etc.), the available processing length is from 36D to 60D. The modular design of the screws allows an optimal configuration of the processing sections regarding dosage of additives and fillers, mixing zones and conveying zones. »



For quick and easy cleaning of the screws, after having disconnected from the cylinder, the drive is pushed backwards. Then, the complete processing unit is laterally swivelled out of the machine (see image on the left of ZK25P). Thus, the screws are directly accessible and can easily pulled for cleaning. This procedure is very space-saving.

The cylinders consist of elements with a length of 6L/D. The cylinder elements are connected with heated hinged flanges. This enables to easily arrange them at different positions, for example in case of modifications of the screw configuration. They have a thermally separated arrangement on the machine housing. The heating / cooling jackets are electrically connected with plugs. Thus, dismantling the cylinder elements is much easier. Furthermore, depending on the function, the cylinder elements are coded, so that the machine automatically recognizes which element is in which position. In the high-temperature version, cylinder temperatures of 500°C



13.1

can be achieved. This allows to process all high-performance plastics at process temperatures of 450°C. The cylinder zones are equipped with high-performance ceramic heating bands. A temperature accuracy of $\pm 3^\circ\text{C}$ can be achieved. ■

ZK E Compounder

For more simple mixing tasks, the E series Compounders (ZK16E, ZK25E) represent an economical alternative to the ZK P.

The image on the left shows a ZK25E, which is equipped with the dosing devices of COLLIN Lab & Pilot Solutions. They are available as volumetrically or gravimetrically conveying units. Moreover, they are designed as twin-screw conveying devices. For different dosing tasks, suitable screw geometries are available.

The ZK E has a main dosing and a side dosing. Additionally, a volumetric liquid dosing is possible. In case of complex mixture compositions, suitable pre-mixtures can be used.



The screws have a modular design. Furthermore, the cylinders consist of elements with a length of 6D. Thus, processing lengths of 36D to 48D can be realized.

As standard, the maximum cylinder temperatures achieve 350°C, as option, 400°C are possible.

The maximum screw speed is 460min⁻¹. ■

Teach Line Compounder



The Teach Line series Compounders (ZK12, ZK16, ZK25) were developed for basic developments, material screening and other laboratory applications. With a throughput of 0.1kg/h (ZK12) to 3kg/h, they are especially suitable if there are only minimal material quantities available.

The image 14.1 shows a ZK25, which is equipped with a main dosing of COLLIN Lab & Pilot Solutions. A second side dosing is possible.

The screws have a modular design. Furthermore, the cylinders have a length of 6D. Thus, processing lengths of 18D and 24D can be realised. As option, with an additional cylinder element, the length of 30D can be achieved.

The maximum cylinder temperatures achieve 300°C.

It could impressively be proven by the ZK12, that the principles between specific energy and mixing quality also apply for these small compounders. Processing lengths of 24D and 36D are possible.

For economic considerations, in the development in the pharmaceutical sector, the smallest possible test quantities will be aimed, since a kilogram material can easily cost several thousand euros. Therefore, the desire for batch weights of approx. 50g – 100 g is great. Besides meaningful mixing results, a test machine should offer quick product changes, quick cleaning and easy and safe handling by the test personnel. Since in basic research, large numbers of tests have to be realized, these desires are understandable.

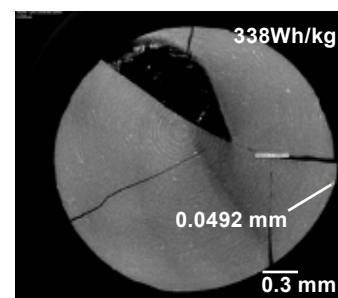
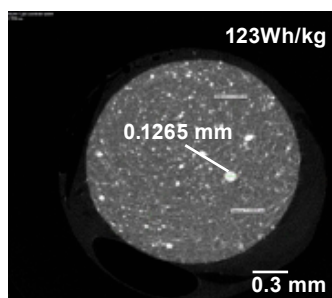
During the development of the machine, special attention was paid to a quick and easy cleaning. With a few simple steps, the complete processing unit can be dismantled.

As part of a term paper at the Chair of Medical Engineering at the TU Munich and the support of EVONIK, the machine was tested /11/. During the test, poly (L-D, L) lactide was mixed with hydroxyapatite.

The batch weight per test point was 100g. Throughputs of 250g/h to 710g/h are achieved. The amount of time per test point was approx. 10min to 20min. Wherein the actual sample production took approx. 5 min.

The specific energy, which is incorporated into the material via the screw, is one important parameter for the mixing effect of a twin-screw. This also forms the basis for a scale up of the process to larger machines. For this reason, also micro compounders are equipped with the determination of the specific energy.

In /11/ the specific energy was directly compared with the mixing quality.



The photos impressively show that this micro compounder clearly fulfils the connection between specific energy and mixing quality. That is the basis for a scale up to larger machines. ■

Pelletizing



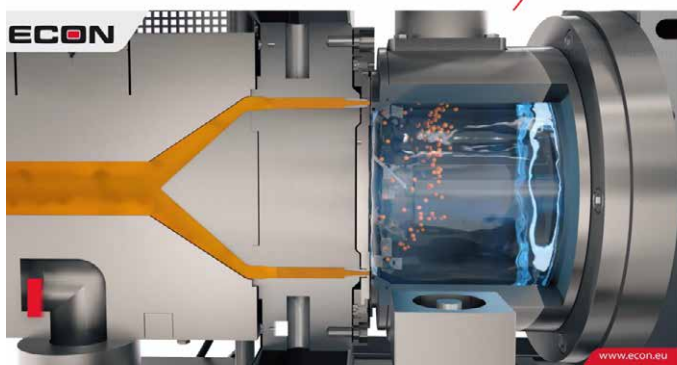
15.1

All processing procedures, if injection moulding or extrusion, are based on the fact that the screws are fed with pellets. These pellets are produced from the melt immediately after the processing. In a strand die, the melt is formed to one or several strands. Strand diameter, strand speed and cutting frequency define the pellet geometry. In principle, there are two procedures

- The strand / strands is / are cooled in a water bath or air cooling section and then cut.
- The strand /strands is / are cut immediately at the outlet die of the compounder and as pellets cooled in a water bath or by air.

Due to the worse heat transfer, air cooling is less efficient but in case of water-sensitive materials, it is inevitable. The water cooling requires the drying of the pellets in any case.

The most efficient type of pelletizing is under water pelletizing. Here, the cutting area at the die plate is washed around by a water flow, which absorbs the melt drops. The large surface, which is available, results in a very efficient cooling. The following image shows the basic principle /12/.



After the water separation, the pellets are guided into the drying area in the machine and the process water is filtered and used again.

Depending on the series, in COLLIN Lab & Pilot Solutions pelletizing lines, the following procedures are offered:

- Teach Line:
Water bath with subsequent strand pelletizing
- ZK P und ZK E:
Water bath with subsequent strand pelletizing
Die face with air resp. water cooling

In image 15.1, the Teach Line pelletizer can be seen. The machine is characterized by its compact design and easy operation.

The biggest line delivered by COLLIN is shown in the following image. Here, it is designed as strand pelletizing line. In this project, also an underwater pelletizing line was delivered as option.



Here, you can see a ZK35P with a processing length of 56D. 4 solids dosing stations plus 3 liquid dosings were installed. Equipped with automatic process data acquisition and recipe management, the line achieved a throughput of up to 150kg/h. »

The common line configuration is a ZK25P or ZK25E combined with an underwater pelletizing system (see the following image).

This line size is an economical solution for the product development. Relatively small batch sizes are used; however, the throughput capacity is high enough to provide sufficient material for further extrusion and / or injection moulding tests. ■



16.1

Direct extrusion

The direct extrusion combines the processing of complex mixtures and the further processing to films, sheets, hoses, pipes etc. in one step. The advantages of this procedure are economic and extremely material friendly. The material is only heated once, which offers a considerable energy saving. Especially residence times critical and / or shear-sensitive materials have a much lower stress since the second processing step is eliminated.

By using the compounder as direct extruder, normally, a gear pump is used. This will compensate the tendency of the co-rotating twin-screw extruder to throughput variations and the high output accuracy specified by the gear pump is achieved. The gear pump is also necessary in order to overcome the quite high pressures in the extrusion die. The pressure build-up capacity of a compounder is restricted to approx. 110bar to 150bar.

State of the art is a pressure speed control.

For this purpose, a pump pre-pressure (approx. 30bar) is pre-set. This is the pressure to be rendered at the screw tip by the screw and is kept constant via the speed of the screw. The pre-pressure is primarily a safeguarding for the pump in order to avoid that it is drained, which can result in damages. In case of a pressure drop below 10bar, the machine will be stopped.

The speed of the pump defines the throughput of the system. Because of the conveying effect of the gear pump, this is almost independent from the pressure consumption in the extrusion tool. With this procedure, with one variable, that is the speed of the pump, the operating point of the line regarding line speed can slightly be modified. This is normally realized with a ramp function.

In the meantime, COLLIN Lab & Pilot Solutions delivers more and more direct extruders. They are often used in coex applications, but they are also integrated in mono lines. The following image shows a design for a mono-flat film:



Another field of application is the foam industry. Here, the propellant is added in liquid form and under pressure in the compounder and very homogenously mixed. In the line shown (17.1), the direct extruder conveys into a single-screw, which acts as discharge device for the die. After having exited the die, the propellant relaxes and forms the foam structure. Then, this is fixed between the calibrating plates and cooled. »

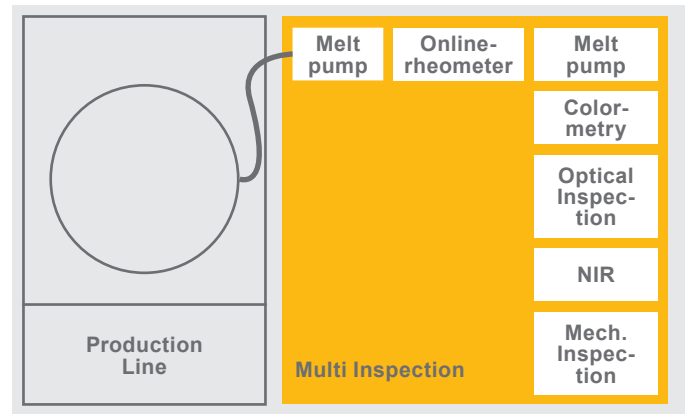


17.1

In pilot lines from COLLIN Lab & Pilot Solutions, the compounder as direct extruder is more and more used. It is mainly used for the direct processing of PET flakes. Thus, this machine is used for the development and test of new layer configurations in blown and flat films. The image below shows a line detail of a seven-layer combi line for blown and flat film. At the right side in the image, the compounder, in this case a ZK25P, which is integrated in the line and which has a throughput of up to 80 kg/h, can be seen.



The EU regulations regarding environmental protection increasingly demand the use of recycled material. So-called „post production“ and „post consumer“ materials are used, which have a wide range of materials and thus offer different characteristics. In order to produce high-quality products, these have to be narrowly specified like virgin material. Since the line sizes and thus the throughput capacities are constantly being increased, an offline test in the test laboratory is too time-consuming. Because from the sample collection to the test result, high quantities of erroneous material are generated under certain circumstances. The result is the motivation for online tests of the important material data such as



17.2

- Viscosity
- Optical film inspection (gel counting)
- Colour measurement
- NIR measurement
- Tension test

For this purpose, COLLIN Lab & Pilot Solutions has developed the „multi-inspection“, which delivers these values at the production machine at the same time. The following image shows the principle in a schematic representation.

During the measurements, absolute values are not important but time constant reference values, which document the quality constancy. Up to 2.5 kg/h of melt is continuously taken and conveyed into a slot capillary for determining the viscosity. For further inspection, at the outlet of the capillary, a film with a thickness of 50µm is formed. The following image shows the inspection system, which is integrated into a recycling line of NGR. All data is automatically collected and can be used for the communication with the production machine or for other evaluations. ■





COMMENT

Customers benefit from a variety of solutions

From breathable films, composite films via tubes for medical technology up to material screenings – COLLIN compounders can be used for many applications. Our customers from different sectors use compounding for product development up to production. The importance of this technology resp. this procedure increases, since with additives, the characteristics of the plastic can be modified – for example to stabilise or pigment a polymer or to influence the flowability.

Since for many customers, only small material quantities are available during the development stage of a product, a reasonable machine solution is required. For this reason,

COLLIN offers compounders and roll mills of the Teach Line series. The compact table-top machines can be run with little material and can perfectly process small quantities. Furthermore, they are available for co-rotating or counter-rotating operation resp. convertible.

The COLLIN Type E Entrance Compounder is perfectly suitable for simple compounding tasks. This stand-alone machine is used for the testing, developing and the production of different polymer materials such as thermoplastics, elastomers, food and for medical & pharmaceutical applications. The compounder can variably combine different polymers and is very flexible with

regard to dosages – side-feeder, volumetric or gravimetric dosing units.

The P Professional series is the high-performance version of the COLLIN compounders, which is used for production tasks by our customers.

Depending on the requirement, our customers find the perfect solution – from small table-top machines up to production lines. The decades of experience, the comprehensive know how and the modularity of our machines speak for themselves. ■

References list

- | | | |
|---|--|---|
| <p>/1/ Polymer – Aufbereitung und Kunststoff – Compoundierung
Carl Hanser – Verlag
10 / 2019</p> <p>/2/ Berücksichtigung der freien Knetoberfläche beim Berechnen von Strömungsfeldern im Kalenderspalt
Sabine Luther
Dissertation Universität Hannover 2003</p> <p>/3/ Meskat, W.; Erdmenger, R.: Vorrichtung zum Verkneten, Gelatinieren und Verpressen von plastischen Massen.
Deutsche Patentschrift DBP 862 668, 1944.
Das Grundpatent zum dicht kämmenden Doppelschneckenextruder.</p> <p>/4/ Funktionale Kunststoffe
Thermisch und elektrisch hochleitfähige Compounds
Meinolf Droege
Kunststoff Magazin, 2021</p> <p>/5/ Spezialcompounds für die Mobilität von morgen
Magnetisch und wärmeleitfähig
Produktmitteilung
Kunststoffe, Carl Hanser Verlag 2021</p> | <p>/6/ "What can be improved by nanometer composites?"
Kamigaito, O (1991).
Encyclopedia of composites materials
Elsevier Science Ltd, 1994</p> <p>/7/ P.M. Ajayan; L.S. Schadler; P.V. Braun (2003).
Nanocomposite science and technology. Wiley.
ISBN 978-3-527-30359-5.</p> <p>/8/ Schneckenauslegung bei der Herstellung von Polymer-Schichtsilikat-Masterbatches
Chemie Technik
Prof. Dr. W. Michael
Okt. 2010
Carl Hanser Verlag</p> <p>/9/ Erdmenger, R.
USP 3 122 356
Gleichdrall-Doppelschnecke mit Dichtprofil und modularer „Baukasten-Bauweise“, 1959</p> <p>/10/ Der gleichläufige Doppelschneckenextruder
Klemens Kohlgrüber, et al.
Carl Hanser Verlag
München 2007</p> | <p>/11/ Patrick Kanters,
Herstellung und Analyse eines medizinischen Compounds aus Poly (L-D,L)-Lactid und Hydroxylapatit auf einem Doppelschneckenextruder Semesterarbeit am Lehrstuhl für Medizintechnik der TU München 09 / 2011
Betreuer:
Dr. F. Grajewski, Dr. COLLIN GmbH
Dr. H. Liedtke, Evonik Industries AG
Dipl.-Ing. Erhard Krampe, Lehrstuhl für Medizintechnik</p> <p>/12/ Pelletizing Is In Our DNA
ECON Präsentation
2021</p> <p>/13/ Praktische Realisierung von Online- Qualitätssicherung in der Kunststoffaufbereitung und im Recycling
Gernot Schaffler
Vortrag anlässlich der Extrusionstagung
Duisburg 2017</p> |
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GUEST CONTRIBUTION



For more than twenty years, ECON has been THE specialist for underwater pelletizing systems. The continuous development of their technology has made them innovation leaders in underwater pelletizing, especially with their patented thermal insulation technology.

Besides underwater pelletizing systems, ECON offers air pelletizing systems, hybrid pelletizing systems and pyrolysis furnaces. Visitors to this year's Fakuma have the opportunity to experience the unique ECON Pelletizing Technology in a live demonstration in Hall A6, Booth A6-6107.

On display will be an EUP 10 Advanced (in combination with a COLLIN extruder), which has been designed to meet the requirements of a 24/7 production. Due to the simple operation and the use of the ECON Thermal Insulation Technology, this machine is ideal for small throughputs (up to 30 kg/hr).

Furthermore, the ECON Pyrolysis Furnace for Screws (EPOS) will be exhibited, which has been developed for an environmentally friendly cleaning of extruder screws and other. The charging chamber has a small diameter, adapted to the size of extruder screws. Thus, the EPOS is a very compact and hands-on version of a pyrolysis furnace, which of course can be used for other parts as well.

- ▶ fast, cost saving and residue-free cleaning
- ▶ low space requirement
- ▶ stand-alone product – only electrical connection needed
- ▶ resource-saving – no process water necessary
- ▶ extended lifetime of extrusion parts and tools due to gentle removal of thermoplastics

The ECON products are not only suitable for compounding & masterbatch applications, but also used in recycling. To meet the needs of the target group, ECON offers tailor-made solutions for every customer. ■



EUP 10 Advanced

Hall A6/Booth#A6-6107
LIVE Demonstration at
11:00am and 3:00pm





LIVE is LIVE

www.econ.eu



Dr.-Ing. Franz Grajewski
Chief Editor

At the RWTH-Aachen, Franz Grajewski studied mechanical engineering with focus on energy technology. After that, he had been working as research assistant at the institute for plastic processing, RWTH Aachen for four years and was responsible for the working group rubber processing. He received his doctorate on process analysis and scale up at internal mixers for rubber processing.

After the doctorate, Grajewski had been working in different leading positions at Alcatel Kabelmetal for 11 years, mainly in the development of products and the production processes needed for the cable connection technology.

Then, he worked at Krauss Maffei Extrusionstechnik. There, he had the responsibility for the optimization and new development of lines as well as processes for pipe, sheet and profile production for 10 years.

From 2007 to 2019 Dr.-Ing. Franz Grajewski was responsible for process technology at COLLIN Lab & Pilot Solutions.

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