

Food extrusion. Innovative solutions for the production of food through experience, process know-how and individual consultation.

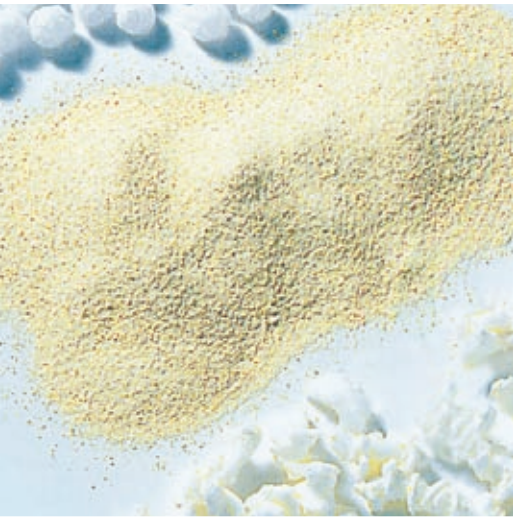
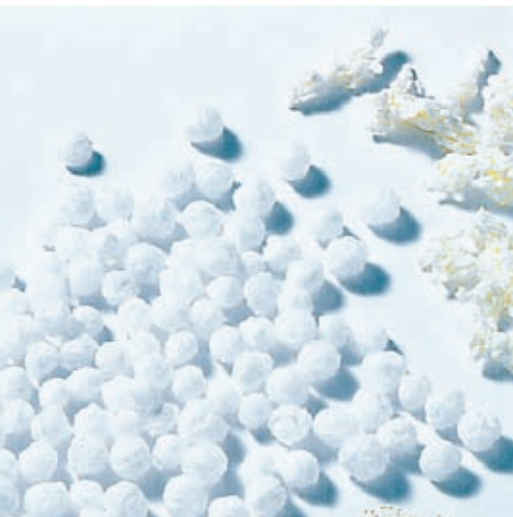
»» A good supplier has to provide more than just good machines and systems. Experience and know-how are required. What makes us a particularly valuable supplier of extrusion systems is the way we adapt every process step precisely to suit our customers' requirements. This is the best way for you to obtain solutions for which we can claim an important characteristic: individuality.

Under the name Werner & Pfleiderer, Coperion has continually set standards in food extrusion – from the UK dough kneading machine to the Continua extrusion cooker. As a partner to the food industry for many years, we have continually expanded our design and process expertise and optimized every detail of our extrusion systems. In collaboration with our partners, we now implement customized systems for food extrusion – from feeders to extruders, granulators to dryers, coaters and coolers. We have detailed discussions with the customer to establish his exact needs and to make sure that each individual process step of a system is custom designed to meet the product requirements.

This starts at the project-planning stage and continues from implementation to commissioning and on to subsequent comprehensive after-sales services. The heart of our extrusion systems is the new twin-screw extruder, the ZSK MEGAvolume PLUS. This series is the leader in extrusion technology. Compared to the previous Continua series, a ZSK MEGAvolume PLUS achieves up to 10 times higher throughput rates. The unique feature of this design is the combination of large free volume, maximum speed and high torque. It opens up a broad spectrum of applications for the gentle and yet efficient extrusion of foods. **That's what we mean when we say "confidence through partnership".**

Coperion milestones in food extrusion

1879	Formation of Werner & Pfleiderer and manufacturing of the first UK kneader
1957	Manufacturing of the first twin-screw extruder ZSK; – among other products for making chocolate
1961	Market launch of the ZPM, the first continuous dough kneader
1972	Market launch of the cooking extruder Continua
2001	Market launch of the ZSK MEGAvolume series
2007	Market launch of the ZSK MEGAvolume PLUS
2008	Merger of Coperion Werner & Pfleiderer, Coperion Waeschle, Coperion Keya and Coperion Hartmann in Coperion

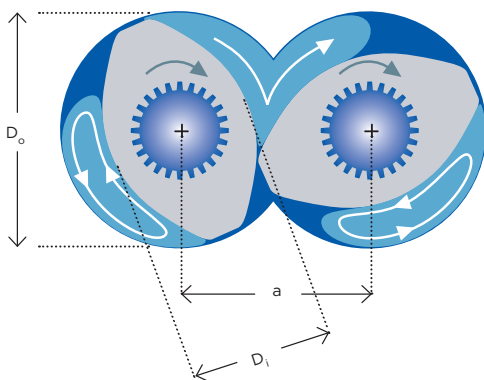


»» The ZSK MEGAvolume PLUS extruder: the heart of your system. With the new ZSK MEGAvolume PLUS, we continue where we left off as Werner & Pfleiderer: with leading-edge technology for food extrusion.

The ZSK MEGAvolume PLUS is setting new standards in food extrusion: the process section of this twin-screw extruder consists of several barrels in which the co-rotating screws operate. The closely intermeshing screws with their tight self-wiping profile eliminate stagnant zones over the whole length

of the process section. The effect of this is a constantly high conveying efficiency and perfect self-cleaning. The unusual combination of free screw volume, screw speed and torque enables the ZSK MEGAvolume PLUS series to provide ideal conditions for the extrusion of numerous types of food.

01 | Cross-section through the two co-rotating screws



D_o = outer diameter | D_i = inner diameter | a = centerline distance | D_o/D_i = outer/inner diameter ratio, determines shear and free volume
 Md/a^3 = specific torque, determines output density and degree of fill | n = screw speed, determines shearing and mixing

➤➤ The whole variety of food extrusion. The modular structure of the ZSK MEGAvolume PLUS allows it to be individually configured for every application. With the complete portfolio, all sizes are available to our customers, allowing them to process any required throughput range from laboratory to production scale.



PRE-GELATINIZED FLOURS AND STARCHES/ BIODEGRADABLE PRODUCTS

PRODUCTION CAPACITIES

Machine size	PRE-GELATINIZED FLOURS Throughput approx. [kg/h]*	PRE-GELATINIZED STARCHES Throughput approx. [kg/h]*
ZSK 34 Mv PLUS	100-200	50-100
ZSK 43 Mv PLUS	200-400	100-200
ZSK 54 Mv PLUS	300-600	200-300
ZSK 62 Mv PLUS	500-1,000	350-500
ZSK 76 Mv PLUS	800-1,600	550-800
ZSK 98 Mv PLUS	1,200-2,400	800-1,200
ZSK 125 Mv PLUS	2,500-5,000	1,700-2,500

* Process and product-dependent, with a residual moisture of approx. 8-15% following pelletizing

➤ **Pre-gelatinized flours and starches:** In comparison to conventional production methods of using a stirred kettle and roller dryer, production of pre-gelatinized flours and starches with a twin-screw extruder has significant cost benefits. Its excellent product feed characteristics allow the ZSK MEGAvolume PLUS to achieve very high throughputs even with small machine sizes. Investment and operating costs drop significantly compared to conventional production methods or to processes using older extruder series.

➤ **Biodegradable products:** Since biodegradable materials were introduced, Coperion's ZSK twin-screw extruder has been heavily involved in processing them. Starch-based biomaterials were created by combining the production methods of extrusion cooking and plastics compounding. In the numerous plants already established for biodegradable materials, Coperion combines many years' expertise in food extrusion with the extensive experience in the plastics sector.



EXTRUDED CEREALS AND SNACKS

PRODUCTION CAPACITIES

Machine size	CEREALS Throughput approx. [kg/h]*	SNACKS Throughput approx. [kg/h]*
ZSK 34 Mv PLUS	200-300	200-400
ZSK 43 Mv PLUS	400-600	400-800
ZSK 54 Mv PLUS	600-900	600-1,200
ZSK 62 Mv PLUS	1,000-1,500	1,200-2,000
ZSK 76 Mv PLUS	1,600-2,400	

* Process and product-dependent, with a residual moisture of approx. 8-15% following pelletizing

The ZSK MEGAvolume PLUS continually provides consistent high product quality in extruding the full range of raw materials for cereals and snacks, from fine flours to whole grains - even for cereals with a high fat content. Its excellent feeding characteristics allow high throughput rates to be achieved. The closely intermeshing screws with their tight self-wiping profile eliminate stagnant zones over the whole length of the process section. The effect of this is an optimum self-cleaning which allows rapid product changes and thus maximum flexibility in the production of cereals and snacks. Raw material preparation such as pre-cooking, addition of moisture etc. are not required and can be replaced by direct steam injection. The process steps downstream are covered in cooperation with our longstanding partners: directly-expanded cereals and snacks can be dried, fortified with flavors and vitamins, powdered or coated in oil/seasonings or chocolate/sugar. Cooked, non-expanded, "cold-formed" pellets are rolled and roasted to make flaked and shredded products.



PET FOOD/TREATS/AQUATIC FEED

PRODUCTION CAPACITIES

Machine size	PET FOOD AND AQUATIC FEED Throughput approx. [kg/h]*
ZSK 34 Mv PLUS	200-750
ZSK 43 Mv PLUS	400-1,500
ZSK 54 Mv PLUS	600-2,200
ZSK 62 Mv PLUS	1,000-3,700
ZSK 76 Mv PLUS	1,600-6,000
ZSK 98 Mv PLUS	2,400-9,000
ZSK 125 Mv PLUS	4,500-15,000

* Process and product-dependent

➤ **Pet food/treats:** Its balance of free volume and high speed range makes the ZSK MEGAvolume PLUS particularly suitable for the economical preparation of dried and semi-moist dog and cat food and treats. Throughputs of up to 15 t/h, combined with very good wear and corrosion protection of the components used, ensure an extremely economical production process within a very broad range of formulations. Depending on the application, steam is added to the solids by a pre-conditioning step or by steam injection directly into the ZSK. The wetted material and further additives are cooked and pasteurized in the plastification zone under gentle conditions at low pressures. Shear-sensitive powdered additives can be added via side-feeders downstream. This bypasses the cooking zone and incorporates the active ingredients extremely gently. The energy introduced and the degree of gelatinization achieved as a result affects the texture of the product which is extruded through a die plate at the end of the extruder. Granulated products are dried and coated in fat, oil or flavors downstream. Treats and chews are cooled and cut to length after discharge.



➤ **Aquatic feed:** Compared to production of aquatic feed using single-screw extruders, the twin-screw extruder is suitable for producing a much broader range of formulations, such as extruding fish food with an elevated fat content, for example. The floating/sinking characteristics of the fish food can be modified by means of flexible settings of different parameters on the extrusion lines. Coperion has already made numerous large extruders with screw diameters of up to 380 mm and throughputs of up to 80 t/h for other materials. As a consequence, Coperion is perfectly set up to handle the demand for increased throughput rates anticipated in the aquatic feed production of the future.

ENCAPSULATION

Coperion has many years' experience and extensive knowledge in the design and implementation of extrusion lines for encapsulating active ingredients such as flavors, vitamins, herbicides or feed additives. The intensive mixing action of the ZSK MEGAvolume PLUS achieves a highly-dispersed distribution of active ingredients. At the same time, kneading and mixing in the twin-screw extruder is at low shear and gentle temperature, achieving a top product quality. The active ingredient develops its effect only when it is used.



CONFECTIONERY

Of its predecessor, the Continua cooking extruder, and of the ZSK MEGAvolume, Coperion has installed numerous lines for producing candy, chocolate or chewing gum. Sample lines include thermal reaction processes to make crumb chocolate or caramel masses (Maillard reaction). The outstanding mixing characteristics of the ZSK MEGAvolume PLUS guarantee that the lines achieve top product quality. In chewing gum a thorough dispersion of the flavor achieves a more intensive and lasting impression of taste.

PHARMACEUTICALS

During melt extrusion of pharmaceutical materials, active ingredients are mixed into binders, carriers and other additives in a co-rotating twin-screw extruder. This continuous process has numerous benefits compared to traditional production methods, such as compacting the materials. These include:

- › reproducibility
- › intensive mixing with a narrow range of residence time in the process section
- › bioavailability due to "solid dispersion" and "solid solution" – in other words, the pharmaceuticals can be administered in tablet rather than injected form.

Coperion has references for pharmaceutical extruders in sizes ZSK 18 to ZSK 70 which are amongst others characterized by the following features:

- › manufactured to GMP design
- › proven certified materials are used (3.1-B certificates)
- › special control system which can be designed to suit the requirements of laboratory operation or clean room production (GMP compliant, incl. certification), depending on customer requirements.

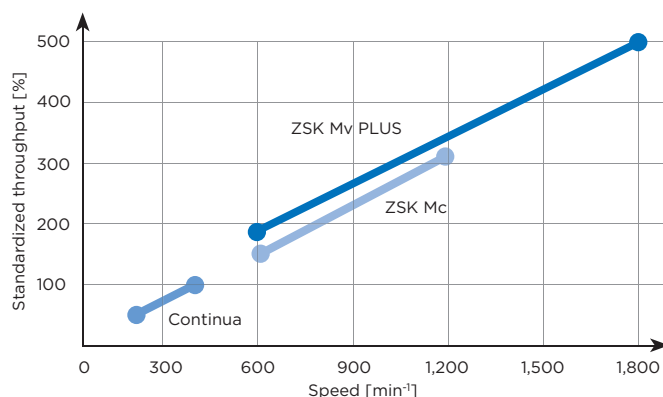
➤ **Screw volume:** The deep-cut screw flights with a diameter ratio D_o/D_i of 1.8 create a very high free volume. This considerably improves the feeding of flours, starches and additives with a low bulk density. Products are also handled extremely gently during the extrusion process.

➤ **Screw speed:** The ZSK MEGAvolume PLUS series is designed for speeds of up to $1,800 \text{ min}^{-1}$. Compared to its predecessors, free volume and throughput rates are several times greater for the same machine size. The economy of food production increases dramatically, as smaller machines with lower investment and operating costs are used.

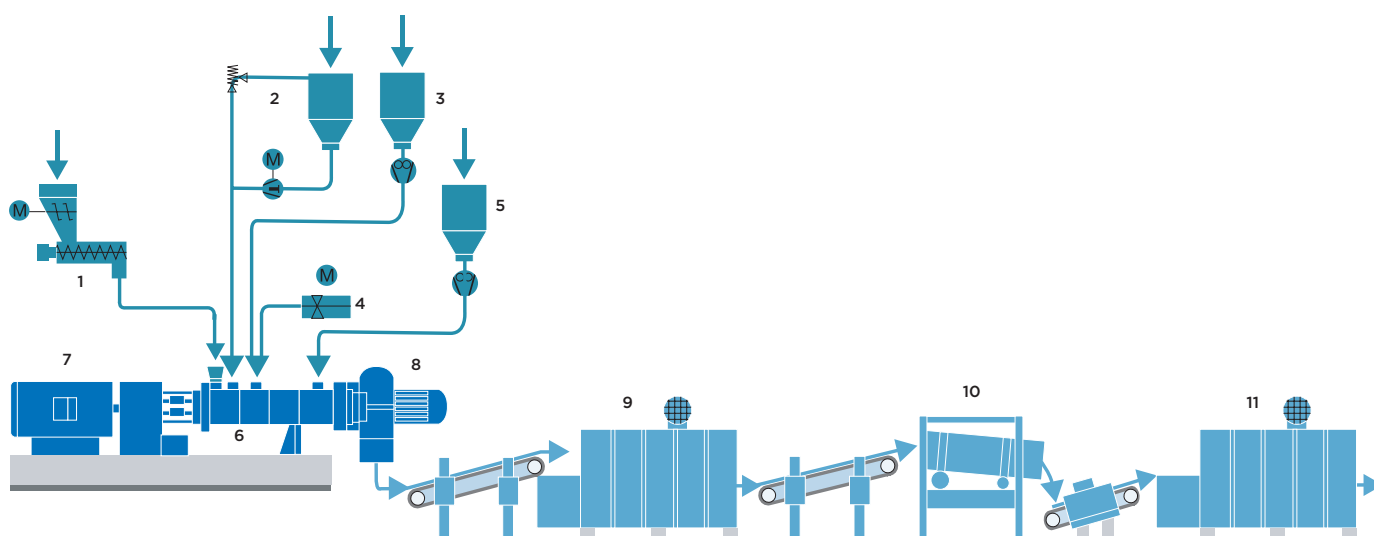
➤ **Torque:** The typical high specific torque Md/a^3 of 11.3 Nm/cm^3 for the ZSK MEGAvolume PLUS allows the flights of the screws to be filled to a high degree. The low shear speed means that products are extruded extremely gently. The high specific torque also allows a broad range of formulations to be run.

The ZSK MEGAvolume PLUS series, with its combination of design parameters (diameter ratio $D_o/D_i \geq 1.5$, screw speed $n \geq 800 \text{ min}^{-1}$, specific torque $Md/a^3 \geq 11 \text{ Nm/cm}^3$) is patent protected in the major industrial countries. For specific areas of application – such as the production of biodegradable products or pharmaceutical materials – the ZSK MEGAcoupler PLUS is used in addition to the ZSK MEGAvolume PLUS; the former is also protected by process patents.

Comparison of standardized throughputs



02 | Production of dry food



1 Solids, powder feed | 2 Liquid feed | 3 Slurry feed | 4 Steam feed | 5 Fat or dye feed | 6 Extruder | 7 Main drive | 8 Die plate, pelletizer
9 Dryer | 10 Coater | 11 Cooler

»» Some people think it's our research department. Actually, it's yours. We design the right process technology and the ideal compounding system for every product as we have found an ideal way of showing our customers today their tomorrow: the Coperion test labs.

Coperion provides test labs for the compounding & extrusion market in Stuttgart (D), Ramsey (USA) and Nanjing (CN). These three test labs are the platform for advanced testing of any challenge of a production plant, like the development of the optimized screw configuration for a new product formulation. Our food test lab at the Stuttgart site is an experimental facility which we designed specifically for the requirements of food technology. A ZSK 43 MEGAvolume PLUS with associ-

ated auxiliary equipment is available for tests here. The applications for this extruder range from the production of direct-expanded breakfast cereals and snacks to the modification of flours and starches to the production of dry animal feed as pet food. Affiliate to our test labs are our laboratories, in which our scientists have access to numerous analysis options to evaluate the product quality in real-time. Proven scale-up methods are used to extrapolate test results to production conditions.

Coperion food test lab in Stuttgart (D)

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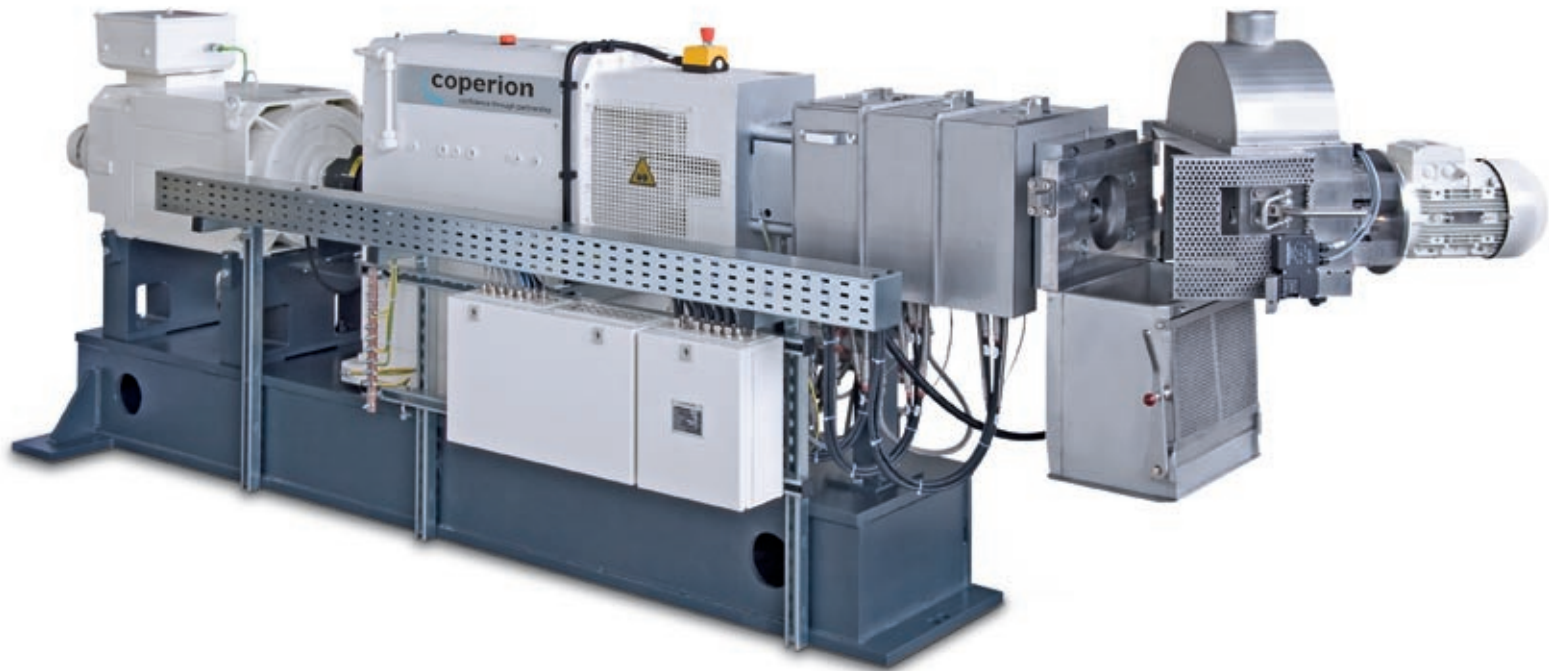


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Compounding & extrusion test labs

Test labs in Stuttgart (D), Ramsey (USA) and Nanjing (CN)
Food test lab at the Stuttgart (D) site specifically set up for food technology requirements
A total of 30 compounding and extrusion systems worldwide permanently available for testing – from laboratory extruder ZSK 18 to ZSK 92
Throughput rates ranging from 1 kg/h to 2 t/h
Affiliated laboratories for real-time analyses of product quality

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