Compounding Systems with Variable Kneading Flights

Further Development of Buss Kneader Technology Opens up New Application Fields

Due to their modularity, the new Buss compounding systems can be configured specifically to meet the needs of the user and are suitable for processing a wide range of products. Flexible configuration of the process section with kneading flights opens up new compounding possibilities.

Market research institutes such as AMI see the innovation and earnings potential in the polymer industry more and more in the production of high quality compounds, i. e., in modifying and improving polymers through the compounding process. The demand for products with improved properties – such as reinforced, scratch-resistant, flame-retardant, weather-resistant and at the same time resource-saving – is steadily increasing. These properties can only be achieved by homogeneously mixing in significant amounts of additives. With that in mind, Buss AG, a manufacturer of continuous compounding systems for over 60 years, decided to further develop its Kneader technology so far used above all for the gentle processing of temperature-sensitive plastics.

Development of the new Compeo series focused on the customer requirements identified in a comprehensive survey as follows: a wide range of applications, a large operating window, high flexibility and robustness, as well as improved process stability, but also operational and operator safety, energy efficiency and reduced operating costs. Compeo also drew upon the consolidated experience gained from several Buss Kneader generations (MKS, quantec, MX). The result is a system that can be configured from standardized modules (**Fig. 1**) for applications well beyond the served

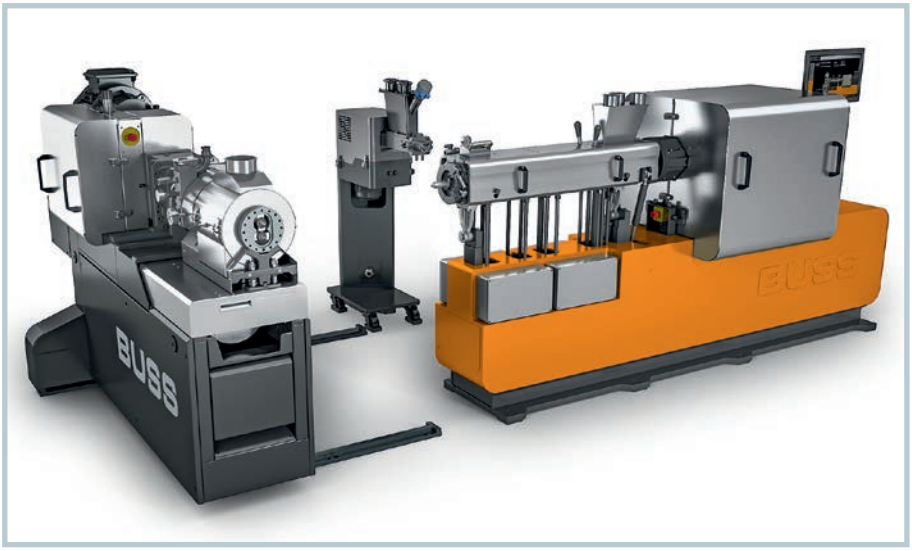

Fig. 1. Compeo pilot plant, consisting (from left to right) of discharge unit, side feeder, Buss Kneader with feed hopper and control panel (© Buss)

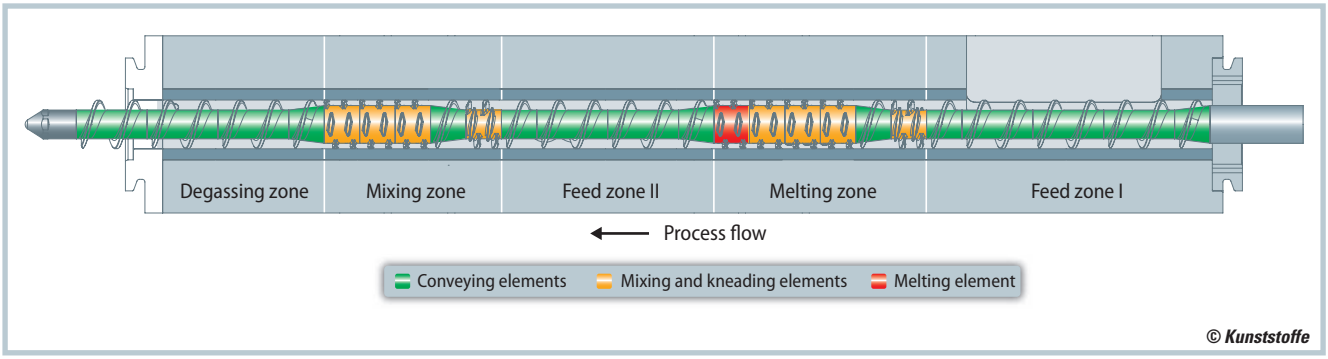

Fig. 2. The process geometry can be optimized by the specific arrangement of different screw elements for the respective compounding application (source: Buss)

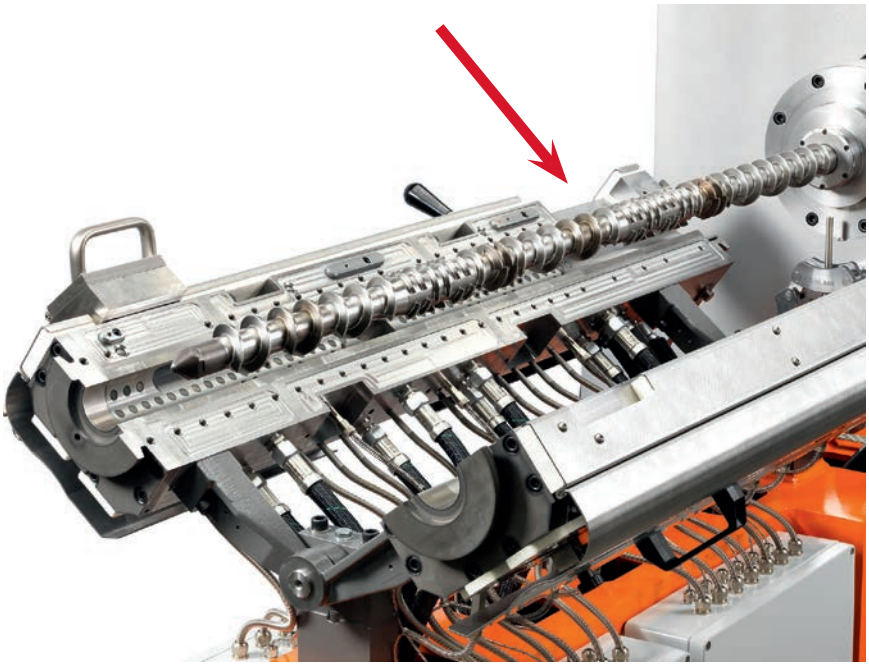

Fig. 3. The 120° opening angle of the process section cover greatly facilitates maintenance work and adjustments to the screw geometry. The intake opening is marked with an arrow (© Buss)

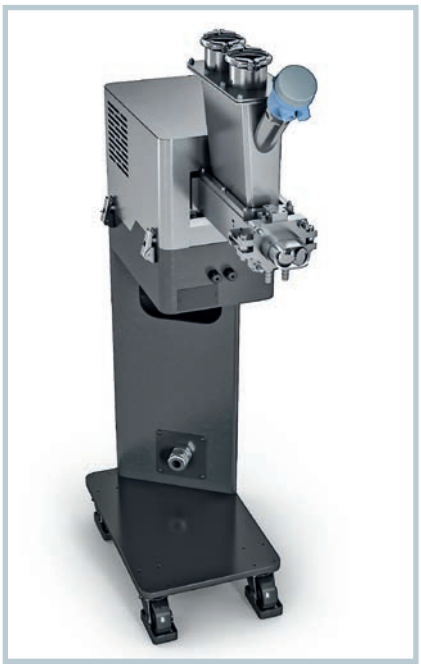

Fig. 4. The twin-screw side feeder with ventilation enables high filler fractions input (© Buss)

market segments such as PVC, cable compounds and thermosets. This opens up compounding possibilities for a broad spectrum of engineering plastics with process temperatures up to 400 °C.

Machine Concept of the New Series

Thanks to its modularity, the Compeo system can be precisely configured to suit specific compounding applications. In the basic version with two intake zones (**Fig. 2**), polymers, additives and some of the fillers are fed through the first intake opening into the process section. In the melting zone, the polymers are molten and mixed with the additives. In the second feed zone, further fillers are added and distributed homogeneously into the downstream mixing zone. Volatiles and air are removed in the degassing zone before transfer to the discharge unit. The processing length, type and number of feeders, temperature, degassing and process geometries are defined according to the compounding application.

When designing the system, emphasis was placed on ergonomics, ease of maintenance, and energy efficiency. Lines and cables are laid as far as possible inside the machine behind easy-to-clean panels. The gearbox is covered with a soundproofing hood that also improves occupational safety. To minimize energy losses, the kneader barrel is thermally insulated. Systematic standardization of the modules used enables up to 30 % investment cost savings compared with predecessor models. Maintenance outlay is minimized by using highly resistant surface-hardened materials in the process zone.

Development of Buss Kneader Technology

With the single-screw Buss Kneader, the mixing and kneading screw performs an axial oscillating stroke with each rotation. This superimposition of rotation and axial oscillation generates extensional flow with highly dispersive and distributive mixing action between the kneading flights and the kneading pins fixed in the kneader barrel. For more than fifty years the first Buss Kneader generations had three kneading flights around the screw circumference. The introduction of four-flight technology in the year 2000 made it possible to achieve significantly higher performance, thanks to the improved conveying stability of overlapping kneading flights. The new Compeo series now enables an application-specific combination of elements with 2 up to 6 kneading flights on the circumference of the screw.

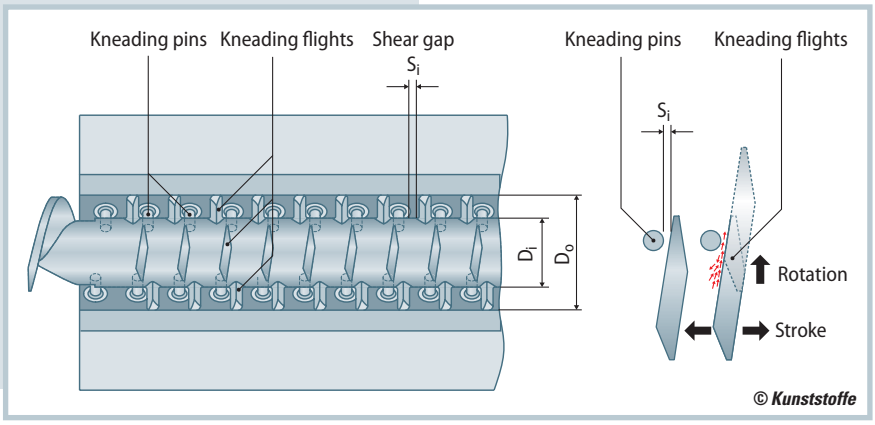

Fig. 5. Screw geometry detail: new melting elements, e. g., for cable applications, replace the restriction ring in the compounder housing (© Buss)

Improved Raw Materials Feed

The intake opening at the beginning of the process zone (**Fig. 3**) has a length ratio of 4 L/D, so that bulk solids can be metered in freefall. In addition, a venting duct for entrained air increases the feed zone filling capacity and relieves the gearbox seal. As an alternative to the hopper, which can be filled through several dosers, a vertical inlet screw or a side feeder can be used.

Depending on the application, up to two additional side feeders can be attached along the process zone. The conveying efficiency of these twin-screw side feeders (**Fig. 4**) ensures stringent feeding even of high filler contents. Backventing removes contaminated air or volatiles. For processing sensitive fillers, the vertical inlet screw alternative is preferable. Liquid components can be injected directly into the product at any position through drilled kneading pins.

Further Developments in the Process Zone

The flexibly configurable process zone of the new compounder (**Fig. 2**) opens up new process engineering possibilities through the availability of mixing and kneading elements with two to six rows of screw flights. By combining existing screw technologies (3 or 4-flight) with newly developed elements (**Fig. 5**), previously conflicting optimization goals – high specific throughput with controllable energy input – can be achieved at the same time. The kneading flight geometry design is based on free-form surface contouring, which maintains a constant shear gap between the kneading flight and the kneading pin throughout the material flow (**see Box p. 2**). This ensures evenly intense shearing of the product and eliminates the risk of local overheating. The new screw geometries, in combination with improved raw material feed, enable the throughputs of earlier models to be reached at 20 % lower speed. The volume-related torque has been increased by 15 %, so that longer mixing zones can be configured. These adjustments improve process stability without any additional increase in energy input.

The new system can be operated in a much larger process window than its predecessors (**Fig. 6**). This enables throughput to be varied in a ratio of 1 : 6 with only one screw configuration, thus enhancing not only plant flexibility but also user-friendliness, for example during startup or with small sampling batches. This high throughput ratio is indispensable for in-line processes such as calender feeding, where the downstream unit requires consistent product quality even with greatly varying throughput rates.

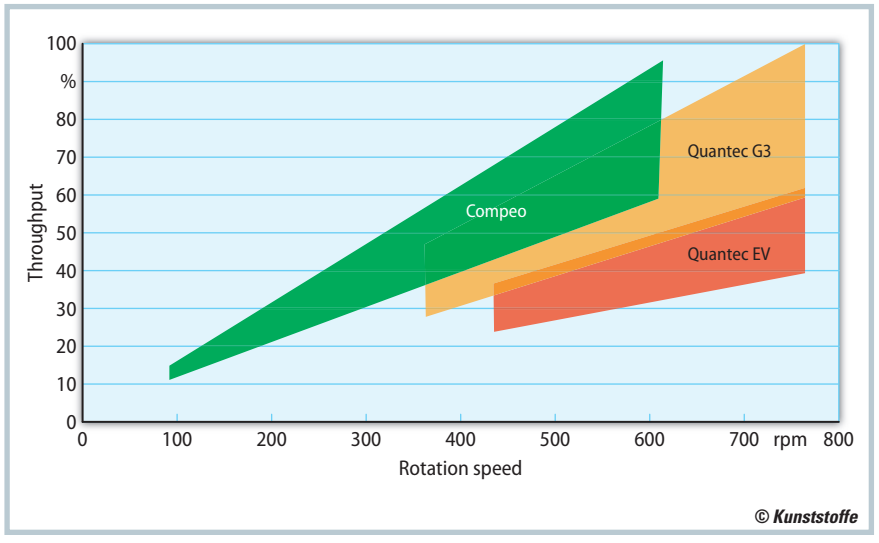

Fig. 6. Compared to predecessor models, the Compeo series offers a much larger process window, here, e. g., for PVC compounding (source: Buss)

Novel Discharge Concept

Buss introduces a new discharge concept that, independently of the compounder, ensures the pressure build-up required for downstream units such as screen changer and pelletizer. The discharge unit, based on the principle of a conical twin screw (**Fig. 7**), is underfed. As a result, the entire pressure build-up takes place in the slowly rotating twin screw, thus reducing temperature increases at the transition from Kneader to discharge unit. Due to the working principle of the counter-rotating twin screw, the conveying rigidity is guaranteed even at higher back pressures, whereby the speed and thus also the temperature increase can be minimized on account of pressure build-up. The housing of the discharge unit can be fully opened so that all system com-

ponents are accessible for cleaning and maintenance.

Control Interface with Industry 4.0 Compliance

The touch-screen equipped system controller (**Fig. 8**) is based on a state-of-the-art Siemens S7 controller and has an OPC-UA interface for connection to higher-level IT architectures. This interface makes the system fully Industry 4.0 compliant. Remote diagnostics and remote maintenance are included as an option. The modular software is structured according to the system configuration and can be operated intuitively. The controller works with stored formulation parameter sets, which makes it possible to switch between formulations virtually at the push of a button. All essential system parameters such as fill levels, flow rates or quantities, pressures, temperatures and outputs are visualized, recorded and archived. It is also possible to continuously monitor defined process parameters such as temperatures, power consumption or specific energy input, and thus the efficiency of the system.

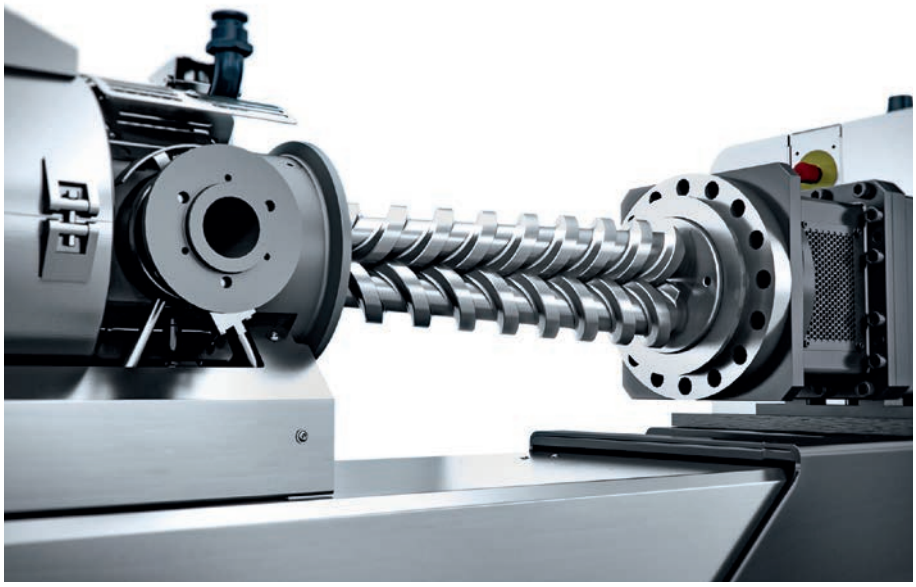

Fig. 7. The twin-screw discharge unit of the Compeo series is used for all compounding applications (© Buss)

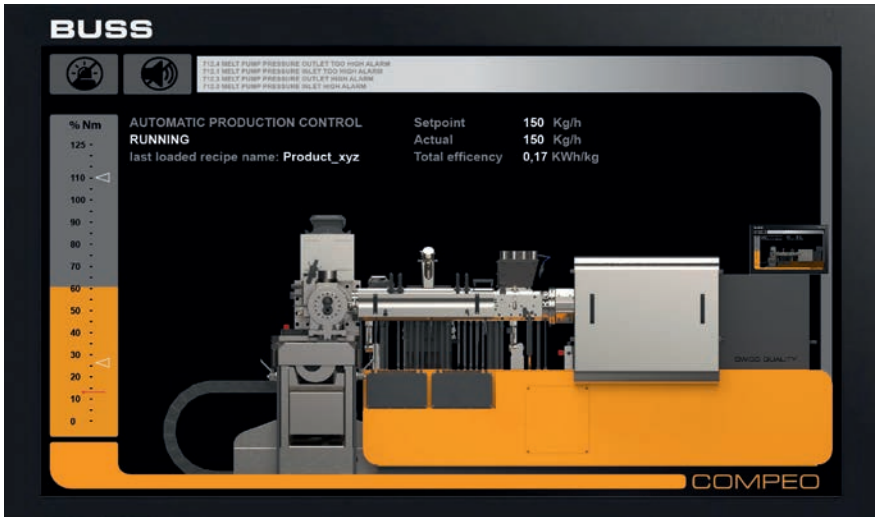

Fig. 8. Start screen: the system controller shows the most important process parameters even when idle (© Buss)

Summary

This modular system concept presented for the first time at the NPE 2018 makes it possible to provide specifically configured lines for numerous compounding tasks, ranging from heat-sensitive thermosets to demanding high-temperature applications. If needed, the Compeo compounder can also be configured as a hybrid system for very different products that so far required two compounding lines.

In addition to its versatility, this new series retains the classic features that are central to Buss Kneader technology, such as intensive mixing, high fill levels and precise temperature control. ■

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References & Digital Version

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