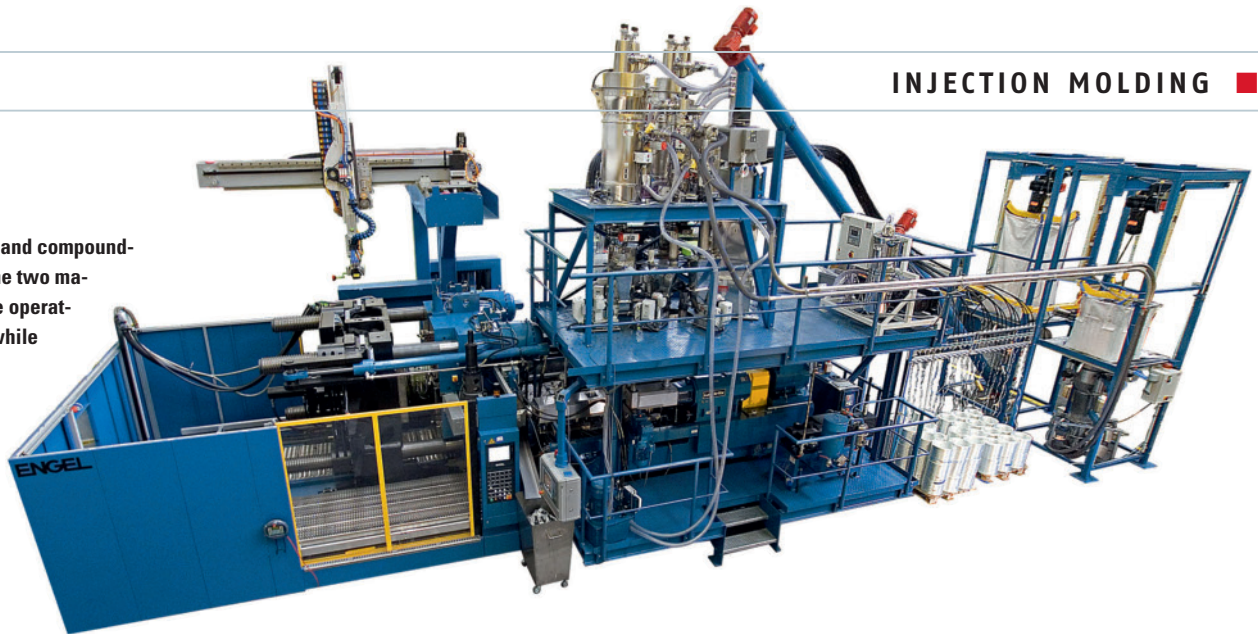


Injection molding and compounding in one step: The two machine parts can be operated separately or while being connected together



Injection Molding and Compounding. To produce large injection molded parts from special material formulations, Engel is offering the modular combination of a standard injection molding machine with an extrusion compounding line. The concept provides maximum possible flexibility to the user: Depending on requirements, the injection molding machine can be operated with commercially available molding compounds or, by attaching the compounder, with special formulations.

When Two Come Together

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Incorporating fillers and additives broadens the property profile and thus the field of application of plastics. Production of material compounds is a common practice in plastics processing, but for economic reasons is generally limited to situations typified by large quantities and a standard assortment. Demand for special compounds, usually involving custom formulations and amounts, will grow to the same extent that plastic applications expand into new niches. Compounds with a high percentage of long glass fibers or powdered additives in particular fall into this category. In keeping with this trend, Engel Austria GmbH has developed a system concept that combines a standard injection molding machine and a compounder in a modular manner. Moreover, the stan-

dard functions of each module remain fully intact; each can, if necessary, be operated independently of the other. Only the combination melds the two standard machines into an efficient system for special applications.

Universal System Concept

Molded parts with a high long glass fiber content as well as a filler level as high as 65 % of high-density material and a certain ratio of virgin to recycled resin are already appearing in bid specifications from automakers. Solutions to problems associated with special requirements can be found with complex material formulations, especially when it comes to confining engine compartment noise or ensure the stability of structural body components. In most cases, this requires material mixtures that are not available commercially and the composition of which must be optimized as part of the development process. Accordingly, the solution in this case is called inline com-

pounding on the injection molding machine and transfer of the plasticated compound directly into the injection unit of the machine. In spite of the special requirements, Engel's own specifications stipulated that the system should not be a single-purpose combination, but rather a universally applicable standard injection molding machine with modular attachments.

The starting point for the system concept, which was actually based on a concrete project, was a large Engel Duo 7050/1000 injection molding machine ▶

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with a 2-platen clamping unit and a clamping force of 10,000 kN. To permit use in more than just general single-material molding, a second injection unit was mounted in a space-saving piggyback position (angled downward) on top of the standard injection unit. In this way, multi-material parts can be produced using commercially available resins, if necessary. However, the opportunities for processing are not supposed to be limited to precompounded resins, but also include the special compounds mentioned at the beginning. Accordingly, the injection unit of the molding machine was coupled to an inline compounder. Within this combination, the melt stream is expected to reach the injection unit via the shortest possible path, so that the compact dimensions make operation and maintenance of the entire system simple. That is what was stipulated in the project speci-

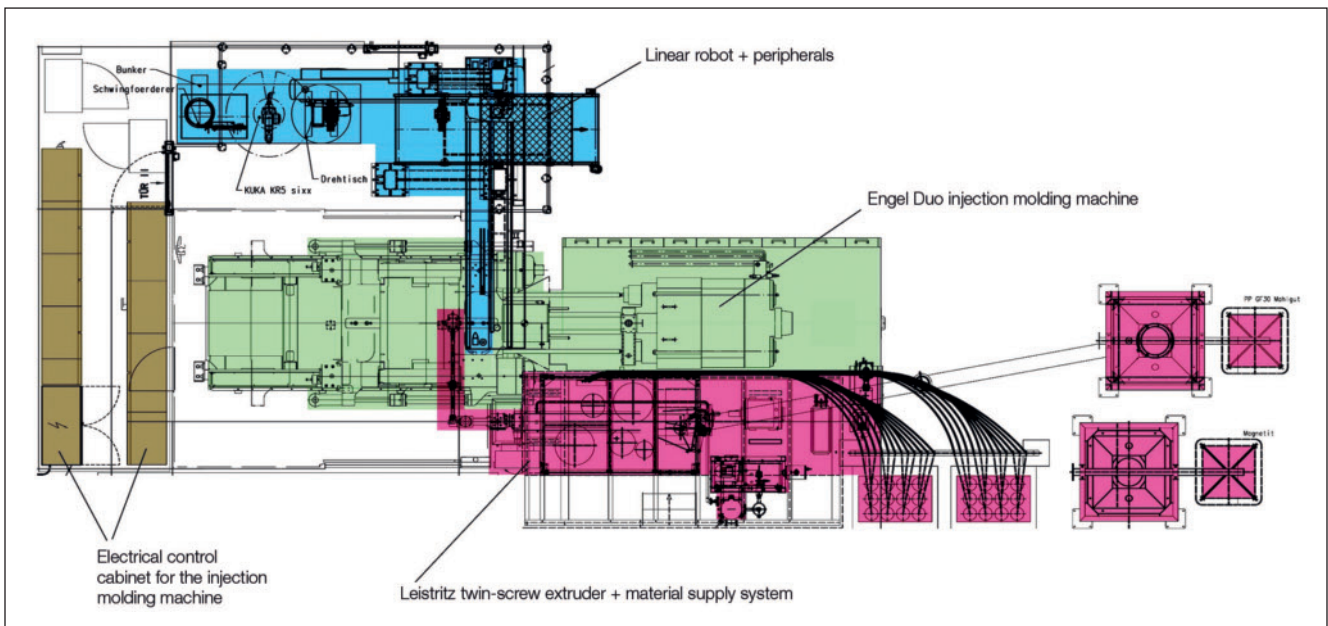
fications. For this reason, the development team chose to place the compounder directly adjacent and parallel to the injection unit of the molding machine.

Combining a Continuous and a Cyclical Process

Equipment components that were close to standard were also to be used in the compounding module. These were designed in collaboration with Leistritz Extrusionstechnik GmbH, Nuremberg, Germany. The starting point here was a co-rotating twin-screw extruder with parallel screws based on a modular arrangement of specific segments that, when combined, formed 50 mm screws (overall length 36D). The extruder is connected to a material conveying and metering station for a total of six compo-

nents – virgin resin, recycled resin, masterbatch, stabilizers, powdered additives with a high bulk density and a feeding mechanism for 24 glass fiber rovings from a spooling station. The necessary conveying and metering equipment is located on a stand-alone mezzanine above the extruder. This arrangement reliably decouples the sensitive weighing systems that are a prerequisite for accurate metering of the powdered additives from operation of the machines, especially the cyclically operating injection molding machine.

Operation of the system envisions combining the continuously operating extruder and the cyclically operating injection molding machine. Starting from the extruder, the plastic compound travels through a horizontal melt conduit to the injection nozzle of the molding machine, which is equipped with a shutoff unit. Using this element, the extruder can either

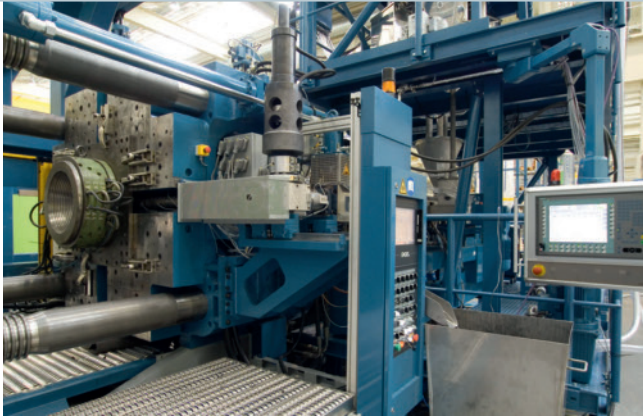


Injection molding combined with compounding: The modular concept for the system consisting of a standard, high-tonnage Duo Series injecting molding machine and a standard twin-screw extruder, including the equipment for material conveying and metering. An Engel ERC Series linear robot with the necessary peripherals is used for the handling of the parts



Overall view of the injection molding system with twin-screw extruder as stand-alone module adjacent to the injection unit of the molding machine (photos: Engel)

connect the material stream or shut it off. Instead of plastication occurring in the screw of the injection molding machine, the extruder delivers the necessary shot volume into the melt chamber of the injection molding machine. Pullback of the injection screw is synchronized accordingly. Upon reaching the set shot volume, the shutoff valve is actuated and the flow of material is interrupted. The screw in the injection unit of the molding machine now injects the prepared compound into the mold and applies holding pressure. During this time, the extruder continues to deliver material into a melt accumula-



The accumulator for storing the melt during the injection process is located at the right end of the melt conduit from the compounder to the barrel of the injection molding machine

tor. After the holding time has elapsed, the conduit connected to the melt chamber of the injection molding machine reopens and the next cycle starts with recharging of the shot volume. At the same time, the material from the accumulator is continuously metered into the melt stream from the extruder and mixed with it. This ensures consistent melt quality.

Easy-to-Maintain Components

The layout of the equipment has the extruder and the injection molding machine positioned adjacent to one another. The centerlines of the two plasticating units are at the same height, namely, 1,700 mm above floor level. This puts all melt-conveying machine components at a readily accessible working height. Maintenance work can be performed without the need for ladders, step stools or lift platforms. The same applies regarding any necessary cleaning of the melt conduit connected to the injection molding machine. Starting from the accumulator head of the extruder, it is oriented transverse to the machine centerline in an intermediate plate – based on a standard mold mounting platen from an injection molding machine – and is thus also readily accessible.



Extrusion system with the feed zone for the glass fiber rovings and the vacuum connection for degassing. The accumulator head for storing melt during injection is located at the front end of the barrel. The barrels of the injection units of the molding machine can be seen in the background

Minimal heights are also a unique feature of this machine concept. The overall height of 6.5 m, which includes the material supply components, does not differ appreciably from the height of a comparably sized machine with part handling robot. The compact equipment layout simplifies maintenance in general and promotes safety during operation. The electrical control cabinets (see layout on page XX) for both pieces of equipment are located away from the machines and the material loaders that are a potential source of dust that could cause problems.

Ease of operation and operating procedures similar to those for standard machines were additional objectives of the development: Both the injection molding machine and the extruder are set up and operated using their standard control panels. All data files in both machines are stored and cross-referenced to the injection molds and material combinations, and assigned a numerical code. Communication between the injection molding machine and extruder employs the “master-slave principle”, i.e. the signals needed for the entire operating sequence are exchanged via an internal interface. As soon as the injection molding machine



Close-up view of the two plasticating modules: at the left, the extrusion system with stand-alone conveying and metering equipment; at the right, the plasticating unit of the injection molding machine. This affords the opportunity to operate the latter independently from the compounder without any technical constraints whenever necessary

transmits the numerical code to the extruder, the corresponding setup parameters are loaded. In addition, both machines are linked to the EMS (Engel Monitoring System). This system records the production parameters continuously, thereby provides complete documentation for the production process.

Great Processing Potential

Gentle handling of the long glass fibers is a major potential of the concept. This becomes apparent when making comparisons with other processing alternatives, for instance, when processing commercially available glass fiber-containing cylindrical pellets, as the glass fibers experience significantly less physical damage and degradation. The major benefit of inline compounding is that, because of the modular design of the twin-screw extruder, the plasticating segments can be matched to provide the ideal balance between gentle fiber handling and separation of the fiber bundle. The opportunity to influence the quality of the fiber in a flexible manner can be exploited to intentionally increase part strength or reduce the use of glass fiber to achieve a particular strength.

Moreover, compared to conventional methods, the benefits are not limited to production of glass fiber compounds alone. The compounder/injecting molding machine creates new business opportunities for production of special parts, especially once a company has built up its own formulation know-how.

Outlook

The production spectrum of injection molding is expanded through combination with compounding. The concept that permits operation of the injection molding machine both as a standard machine and with the compounder in addition to use in multi-material molding gives a new dimension to the term flexibility. With the expanded opportunities for producing parts and the reduction in energy consumption, this approach holds potential not only for special cases, but also for a wide range of applications. ■

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