USE OF CO-ROTATING TWIN SCREW EXTRUDERS IN THE AUTOMOTIVE SECTOR FOR COMPOSITE AND IN-LINE PROCESS APPLICATIONS

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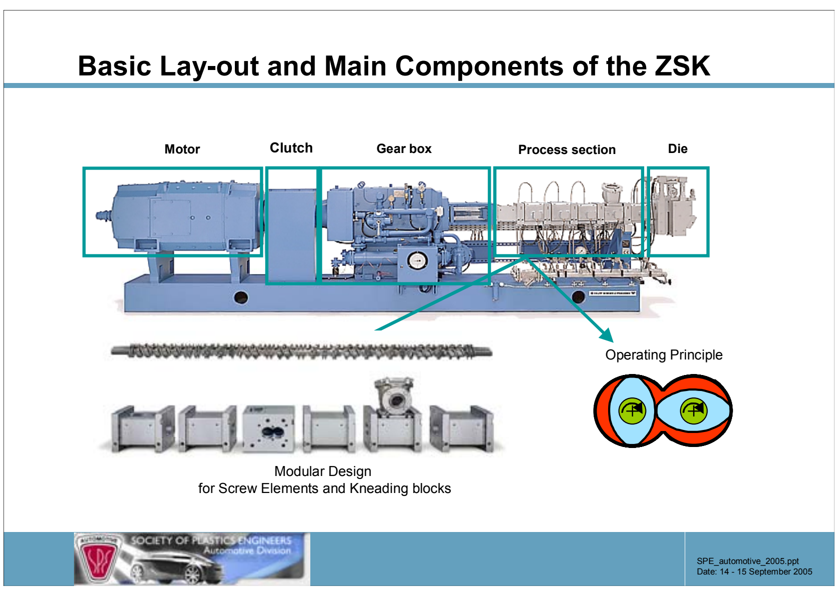
Abstract

Co-rotating Twin Screw Extruders, while mainly used in plastics or polymer applications, have also penetrated several different niche markets, such as chemical or food processing. One of these market sectors where co-rotating twin screw extruders are used is in the direct extrusion, In-line compounding of specialty materials. There are various applications in the automotive industry where co-rotating twin screw extrusion and other processing steps are combined to successfully produce automotive composites and other “In – line” products. This paper gives an overview about such applications/ processes.

Twin-Screw Extruder – Key to the successful process

The fully intermeshing co-rotating twin-screw extruder used for compounding is based on a modular design and consists of the following main components:

- Main drive;
- Gear box with axial bearing and recirculating oil-lubrication system;
- Process section
- Discharge components.



Picture 1: Basic Lay-out and main components of the ZSK

The process section of the ZSK is comprised of several types of barrel sections arranged in an optimal sequence for each specific processing task. The screw configuration located inside the barrel is designed from a great variety of conveying, kneading and mixing elements, which are assembled on multi-spline screw shafts.

In-Line compounding

In-line compounding is a very economical production process. First, it is very gentle on the material because the shear stress of re melting is removed. Additionally, the thermal stress from a second melting is eliminated.

Second all the energy costs for the cooling and re-heating of the material are deleted. Such in-line systems are installed in several areas of the plastics industry, especially in film and sheet extrusion, but also in the compression and injection molding area.

LFT (Long Fiber Thermoplastic Materials)

In the automotive industry, long fiber reinforced thermoplastics could be used as a base material for the production of multifunctional components such as dashboards, sound insulation and underbody panels. The most important reinforcing agents, apart from glass fibres, are natural fibres which are increasingly used in the automotive industry, as well as wood flour and fibers. For household appliances and garden furniture, talc and calcium carbonate can be used as fillers and reinforcing agents.

The broad spectrum of base raw materials is reflected by the range of possible applications for in-line compounding and injection molding or compression molding of long fibre reinforced plastics. In the automotive industry for example:

- Components for none visible parts such as noise shields, underbody panels
- Car interior parts such as dashboard frame, window frames and car seat support structures
- Car body components such as bumper supports, front ends, side panels

With a plant for In-line compounding, injection molding or compression molding it is possible to produce such long fibre reinforced components in a single process step directly from the base raw material. This results in a greater flexibility with regard to the design of the molded part, raw material choice and quantity of reinforcing agents used. Also compared with the conventional two step process, material and production costs are reduced.

Process Principle

A unique screw configuration was developed specifically for long fiber technology to ensure the following:

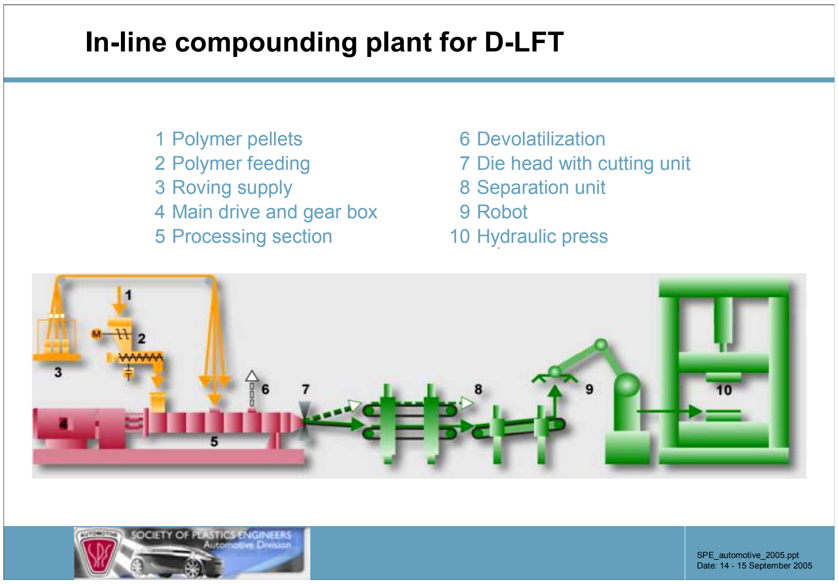
- First, melt the matrix polymer
- Second, polymer melt is mixed and homogenized under minimum stress conditions
- Finally, the continuous glass filaments are automatically pulled in by the rotation of the screws, impregnated with the melt, cut to length and dispersed.

Upstream of the extruder, a gravimetric feeder for the matrix polymer is provided and, if necessary, gravimetric feeders for additives and pigments. The formulation ingredients are accurately fed as a continuous stream to assure consistent composition so that formulation reproducibility is always guaranteed.

The glass fiber filaments are pulled from roving bobbins into the twin-screw extruder by the rotation of the screw shaft. The screw configuration design, has been specifically matched to the viscosity of the polymer matrix and the roving, to ensure uniform intake, sufficient impregnation and dispersion of the filaments as well as uniform distribution of fiber length in the plasticized material prior to molding. Each roving is monitored separately so that a break or interruption is detected immediately and alarmed in the control system. The limits for shutting down the process can be adjusted at the control panel, so that the quality is assured at all times. The roving supply is designed in a way that the line does not have to shut down to change from one bobbin to another. Each roving supply unit consists of one active and one passive palette.

D-LFT- (In-Line Compounding and compression molding process)

After compounding, the plasticized material is continuously discharged through a sheet die. The process step of making the complete stock of blanks ready and available to the discontinuously operating press is technically sophisticated. Special heated cutting and conveying equipment is provided to transport the extrudate and cut it into individual blanks. These are stockpiled by the system and kept at a sufficient temperature until the proper number of blanks has been extruded and cut. Then the complete stack of blanks is discharged onto a feeding belt. Immediately before the molding operation, the blank is picked up by a robot with gripping needles and placed in a press mold.



Picture 2: In-line compounding plant for D-LFT

The entire line is controlled via a touch screen interface which gives the operator an overall view of this complex process, from feeding, to compounding, to preparing and delivering the blanks. Additionally, equipment such as the press and other handling operations can also be viewed from the touch screen. The screen permits the operator to view either the complete plant or a plant section, to check all process parameters and to intervene, if necessary.

The central control system also includes recipe management and order specific process data acquisition software. Particular attention is given the behavior of the line in case of a fault, in particular at start-up and shut down. If there is only a short interruption, molding and compounding will continue. In case of a longer outage compounding is also interrupted. This means that the twin screw compounder filled with material must restart at full load after the fault has been eliminated. The high torque of the MEGA compounder permits this.

Also the high torque feature allows the extruder to simply be switched off at the end of a shift. For restarting, the machine is first heated up and then put into operation at full load. Only the material extruded for approx. the first minute will be degraded and has to be rejected.

S-LFT (In-Line Compounding and injection molding)

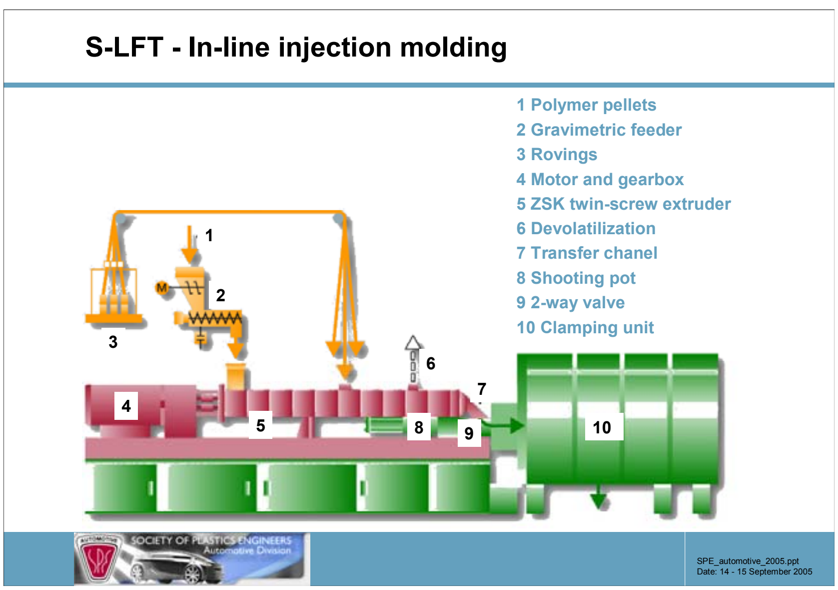
The process of In-line compounding and injection molding is suitable for almost any typical combination of matrix polymers with fillers and reinforcing agents. Tests are currently being performed with PP, PA, ABS, PET as base materials.

A typical clamping device is used. The conventional single screw is replaced by a twin screw extruder which plasticizes the polymer, pulls in the glass fiber rovings by the rotation of the screws, incorporates them into the melt, and fills a shooting pot where the pressure necessary for the injection is built up.

Upstream of the extruder, a gravimetric feeder, a feeder for small quantities of processing aids and additives, and a unit for feeding of glass fibers from the roving are arranged.

The system is built from components already proven in other production applications. The extruder is a standard plastics compounding machine available in many sizes. The injection molding shooting pot is used in all system for injection molding of PET performs, big volume component parts and for injection molding of thin walled packaging materials.

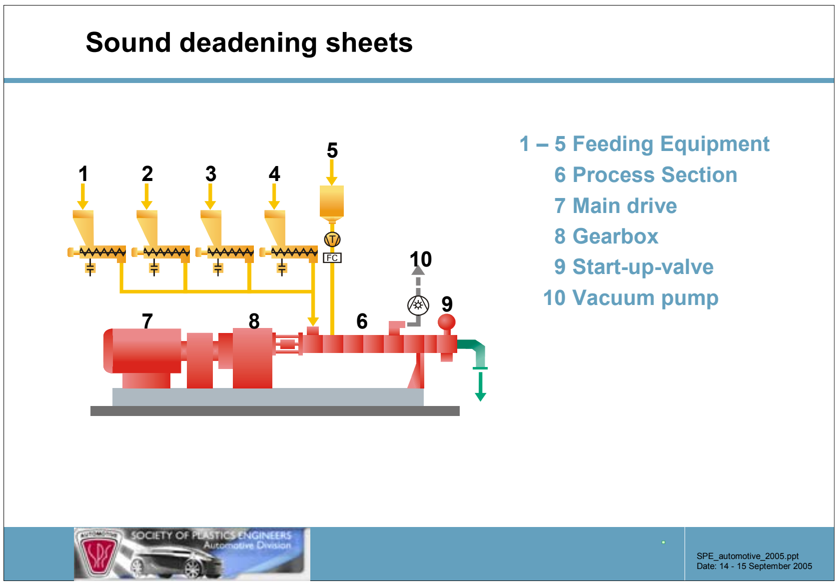
The twin-screw extruder compounds the product formulation in an intermittent mode to match the cycle of the injection molding machine. At the end of the clamping cycle, the compounder starts under controlled conditions and begins plasticizing. The molten glass fiber reinforced compound is metered into the shooting pot. After the requisite shooting volume has been reached compounding is halted. The system can be operated like any other injection molding machine.



Picture 3: Plasticizing and injection molding plant for S-LFT

High density acoustic insulation and sound deadening products

Highly filled sound insulating compounds are used in the automotive industry to insulate engine and road noise. The extruded sheets, sometimes covered with fleece, foam or carpet, are shaped into the correct form on presses or by vacuum drawing, and are then cut.



Picture 4: Schematic set up of a plant for production of sound deadening sheets

The traditional method of producing insulation compounds which fed an agglomerated premix of solids into the first barrel of the extruder, is now increasingly being replaced by a split-feed process. In this new process, as with traditional production, the main polymers / elastomers plus minor components and a portion of the liquids are fed into the first barrel – albeit gravimetrically weighed and introduced as separate feed streams. Abrasive fillers are added downstream via a twin-screw side-feeder into the already molten polymer.

The advantages of this method lie in the safe handling of the raw materials and the associated improvement in product quality as well as significantly longer extruder component lifetime and therefore lower wear parts replacement costs.

Natural and wood fibre composites

Wood fibers and Polymers belong to the most important materials of our time. Both materials have advantages as well as disadvantages, especially with respect of durability, mechanical properties, swelling, thermal resistance and potentially limited availability as a longterm resource.

The combination of wood fibers and polymers opens up the possibility to unify positive properties of both materials and to reduce the negative ones. Because of this, it is possible to produce totally new materials and save resources. The field of use is within the classical applications of wood and polymers, especially for house interiors, the automotive industry and exterior components for the building industry.

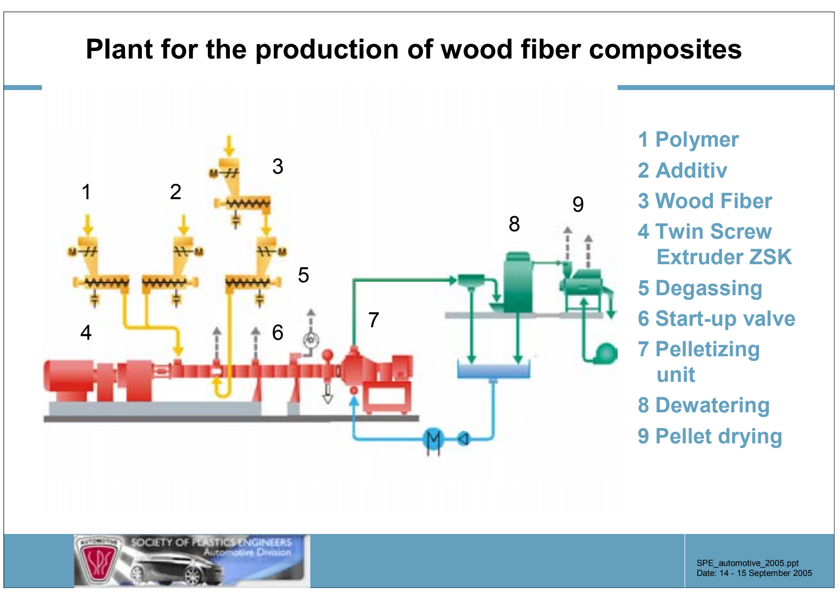
To maintain the aspect ratio of the wood fibers it is best to feed them into the already molten polymer. In this process the polymer and the additives are fed into the first barrel and then melted as the first unit of operation. The wood fibers are downstream fed with a side feeder into the twin screw extruder. The maximum permissible moisture content is about 3%, so the fiber has to be pre-dried. The wood fibers and the polymer are intensively mixed and the fibers are impregnated with the polymer using a special fiber sensitive screw configuration. A subsequent vacuum degassing section removes the volatiles.

After compounding several different production steps can follow:

1. At the discharge of the ZSK a pelletizer could be mounted and the material pelletized. In a subsequent process the pellets can be used for profile extrusion or injection moulding

2. A flat die could be mounted on the ZSK and the material will be extruded onto a calander or a double belt press for in-line production of films or plates

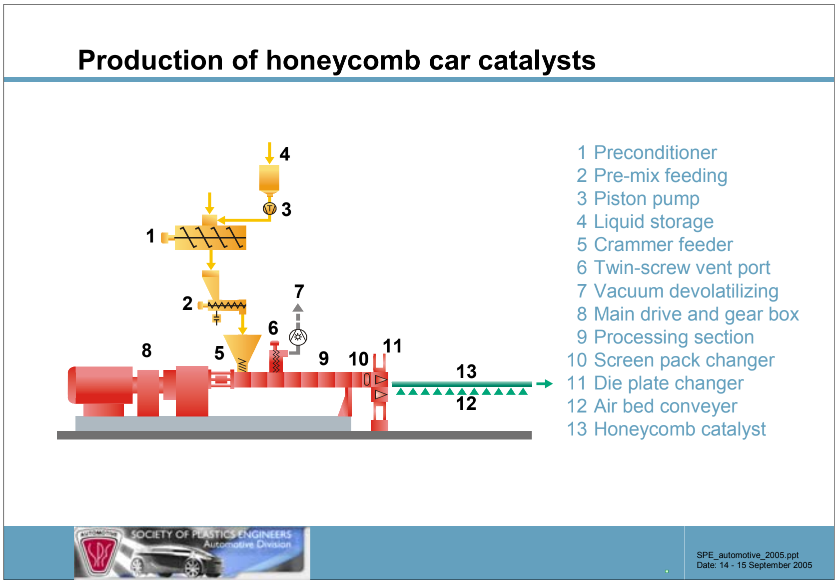
3. After the compounding with the ZSK a profile can be produced in-line. Therefore a profile tool and a calibrating system is located after the ZSK.



Picture 5: Schematic set up of a "long" wood fiber reinforcing plant

Ceramic substrates for catalyst carriers and filters

For the production of honeycomb car catalysts the process scheme with a ZSK is seen in the following picture.



Picture 6 Production scheme for honeycomb catalyst

The pre-mix of ceramic powder, water and coupling agent is fed into the Extruder through a feed hopper with a crammer device. Low shear screw elements brake up the powder agglomerates and the mix is plasticized into a high viscose mass. The kneading intensity of the mixing directly influences the distribution and size of the pores in the extrudate and the resulting activity of the catalyst. The heat which is created by the kneading and the discharge pressureization needs to be removed through intensive cooling because the coupling agent is stable up to 32°C. A twin-screw degassing unit removes the remaining air. At the discharge the material is shaped to form by a die head.

Conclusion

The co-rotating twin screw extruder ZSK, as seen before, is used in many applications with different materials and needs. All these applications are within the automotive industry and therefore the equipment has to achieve specific requirements set by the automotive sector. The OEM's in the automotive industry have high expectations from their suppliers and also challenge them with many different demands and tasks.

Specific materials are to be developed and produced for each OEM and depending on the car model, at top quality with high expectations on the material properties (Crash, environment, health, look etc.). Also each year the supplier has to reduce the costs. In addition there is a huge competition between the suppliers on short production cycles for the car models and therefore, for short amortization time of the equipment as well. At the end, the OEM's lean more and more towards the out-sourcing of the development to the suppliers. All this demands specific attributes which the equipment for automotive applications has to fullfill → *Flexibility, Quality, Economic Efficiency, Reliability, Productivity*.

With co-rotating twin screw extruders such as the ZSK, it is possible to reach these requirements. The machine system is *flexible* in a way that the machine can be adapted to different applications. By using In-line processes the production can be more *economical and efficient* without quality loss to reach *cost reduction*. For just-in-time and just-in-sequence delivery the machines must have a high *reliability,* which is ensured by a high *quality* standard of the machines. The high machine quality standards are the basis for a good product quality to reach the material properties and the productivity which is needed for economic efficient manufacturing. To improve the competitiveness of your own company it is possible to develop and keep know-how on material development and formulations.