Layer by Layer

battenfeld-cincinnati use FloEFD™ to Model High-spec Extrusion Pipes

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battenfeld-cincinnati is a global extrusion systems manufacturer with production facilities in Bad Oeynhausen and Kempen (Germany), Vienna (Austria), Shunde (China) and McPherson, KS (USA).

Energy efficiency, conservation of resources and reduction of material consumption are topics that battenfeld-cincinnati has long been focusing on. As a member of the VDMA's Blue Competence Initiative [2] they play a part in promoting sustainable economic development. Their aim is to provide "leading solutions" to their customers, both in terms of performance and energy efficiency.

battenfeld-cincinnati manufactures energy-efficient, high-performance extruders and complete extrusion lines according to customers' specifications and has found practical, innovative solutions for developing components and tooling. battenfeld-cincinnati is the market and technology leader in Polyolefin (PO) pipe extrusion, particularly for large diameter pipes. Numerous projects for lines with diameters of up to 2.6 meters at a wall thickness of 100 mm have already been realized and successfully placed in the field. Other products include extrusion lines for smaller pipes which are used in telecommunications, where the smallest dimensions can be up to a diameter of 4mm at a wall thickness of 0.5 mm with an extrusion speed of up to 200 meters per minute, building services (such as underfloor heating), and automotive applications, among others. These can have several different layers and various color stripes.

For over a decade FloEFD 3D Simulation Software has supported battenfeld-cincinnati engineers in their product development. We met with Heinrich Dohmann (Head of R&D Pipe Heads and Mechanical Engineering Downstream) and Carsten Bulmahn (Mechanical Engineering Pipe Heads) from battenfeld-cincinnati. "The current short project lead times between ordering and hot-commissioning require the use of advanced simulation tools like FloEFD," explains Heinrich Dohmann.

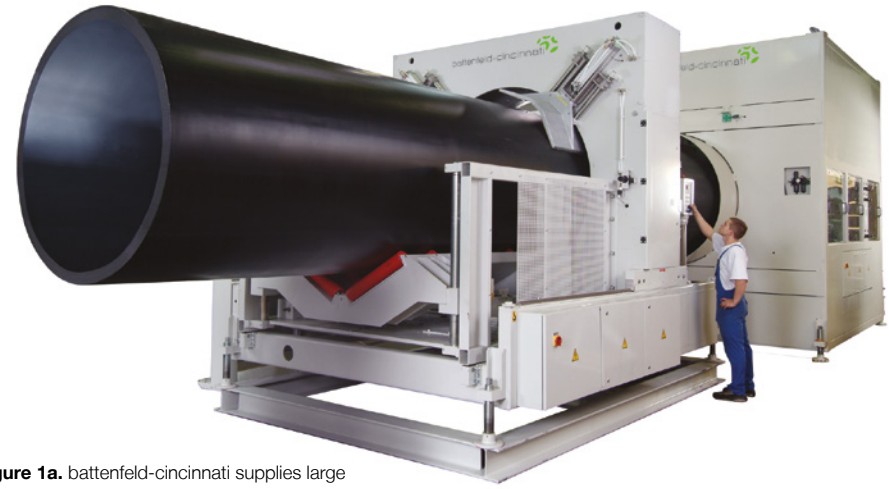

Figure 1a. battenfeld-cincinnati supplies large diameter pipe lines with diameters up to 2.6 m (photo © battenfeld-cincinnati)

Designing and building large diameter pipe heads is a huge challenge. battenfeld-cincinnati is driven by a customer-centric approach to design solutions, whereby customers can select the most suitable pipe head for their specific application from a wide range of tooling options. In the early days, battenfeld-cincinnati used FloEFD for melt distribution optimization. The increasingly complex geometries could not be calculated with the available, reliable tools anymore. Hence, the implementation of a 3D simulation tool became necessary. In addition, a confidential development project in co-operation with an established pipe manufacturer was successfully developed with the usage of FloEFD. Since then, battenfeld-cincinnati has applied FloEFD to a wide range of applications to achieve a uniform velocity distribution in the annular gap at the melt die outlet. The challenge here is to optimize the pressure drop simultaneously. This can amount to up to 400 bar for the entire line and thus has a significant impact on the overall efficiency and the installation space required. The shear flow and the material dwell times have to be considered accurately at the same time.

One of battenfeld-cincinnati's innovative products is the high performance "helix VSI-T+" pipe die. With its two-step distribution concept, it is a highly efficient solution that has proven itself in more than 600 dies worldwide. It consists of a spiral mandrel and a lattice basket distributor element,

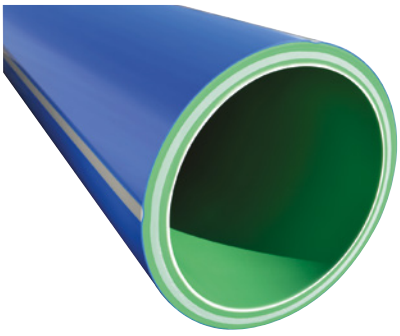

Figure 1b. battenfeld-cincinnati offers a variety of co-extrusion solutions and multi-layer pipe heads for special applications. Pictured: 4-layer PP-RCT-Pipe with glassfibre reinforced centre layer (photo © battenfeld-cincinnati)

Figure 1c. 5-layer PE-RT pipe with EVOH oxygen barrier layer (photo © battenfeld-cincinnati)

for which battenfeld-cincinnati holds the patent. Thanks to the two-step concept the melt is ideally distributed and optimally homogenized. This allows a smaller design for the distribution component, while at the same time ensures excellent pipe quality

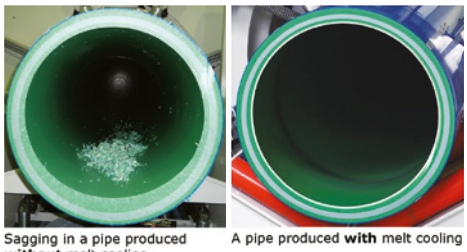

Figure 2. (© battenfeld-cincinnnati)

and high outputs. With the help of PTC Creo embedded FloEFD, the battenfeld-cincinnati engineers give the pipe heads their ideal dimensions. Material flow channel and steel parts are designed compactly and efficiently. battenfeld-cincinnati's helix VSI-T+ die features active internal melt cooling to reduce melt temperatures already in the die and a reduced sagging effect, which is a big advantage in producing pipes with large wall thicknesses and a high line output.

The pipe head is one of the key factors for the customers. Its design and features ensures the production of large pipes with even wall thickness distributions and reduced pipe ovality. It also reduces sagging significantly (see figure 2). The efficient cooling concept allows for shorter cooling lengths in the line and thus enables space savings. The complete line components are custom-made and produced at battenfeld-cincinnati's manufacturing facilities.

Another application for the FloEFD flow simulations is in the development of multi-layer (co-extrusion) tools. In this process, several different layers are produced. In direct extrusion up to seven layers and in coating up to five layers can be produced. Various color stripes can be introduced into the pipe. The quality requirements are also very high in this case. Even the slightest deviations of the tone and thickness of the color stripes are not accepted. "In addition to the time optimization the simulation supports us in terms of product quality and reliability, such as at the color stripes. The detailed engineering is carried out within our development processes in the same team," says Carsten Bulmahn.

With CAD embedded FloEFD the battenfeld-cincinnati engineers can directly use the native 3D CAD data. The fluid space is automatically captured and the mesh is generated automatically from just a few settings within the software. Special calculation models for non-Newtonian fluids are applied for the simulation of the used materials. In this specific case the Carreau model is applied. The parameters for the non-Newtonian fluid model are determined on the basis of customer supplied material samples.

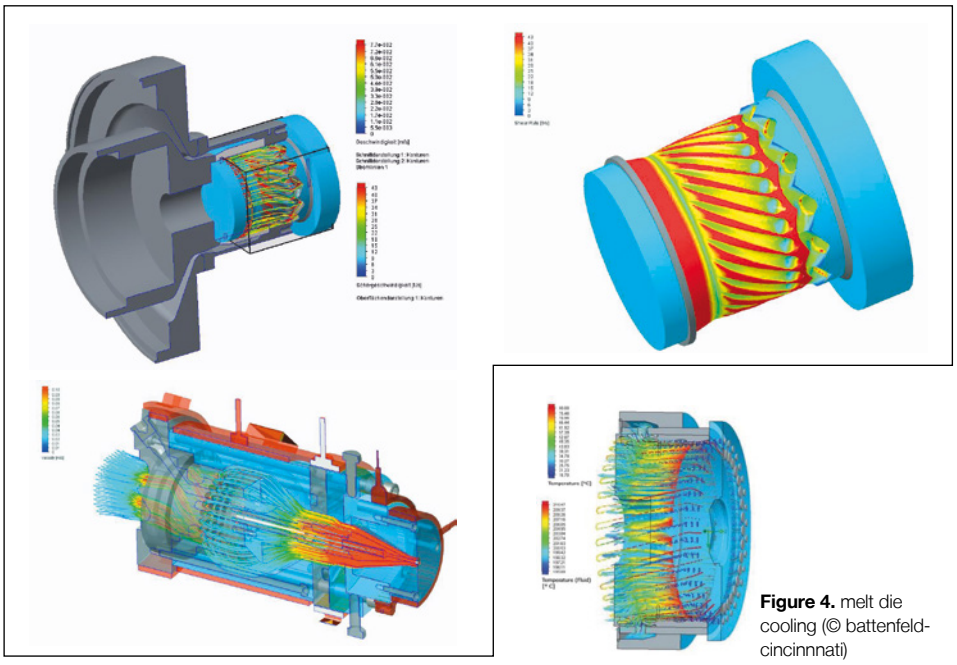

Figure 3a, b, c. melt flow throug the melt die (© battenfeld-cincinnnati)

Figure 4. melt die cooling (© battenfeld-cincinnnati)

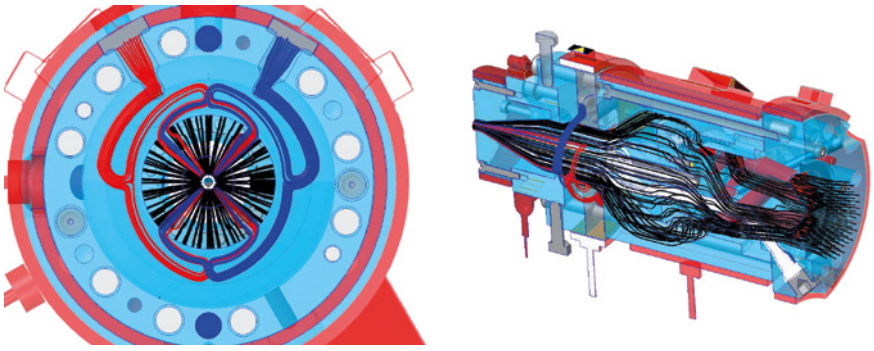

Figure 5a, b. Inner layer, middle layer (grey and black) and two color stripes (blue and red, depending on operating status) (© battenfeld-cincinnnati)

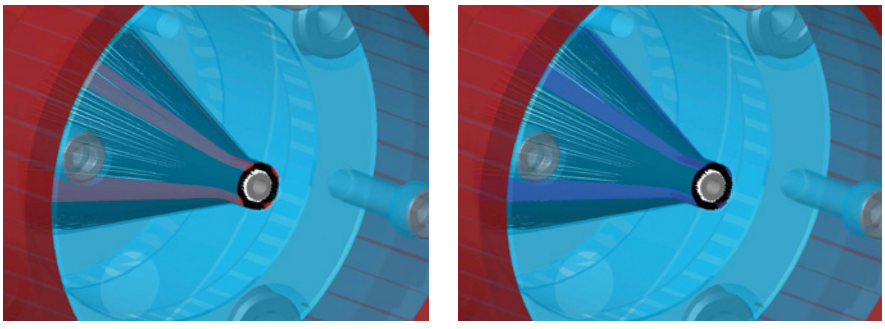

Figure 5c, d. melt distribution at the die outlet

Future conceivable applications where FloEFD might be used, are granulate preheating and pipe cooling. Both are examples of the energy optimization of the overall process. For granulate preheating the waste heat can be re-used in the process. The pipe cooling can already be ensured, but there may be potential for a further reduction of energy consumption and thus increasing overall efficiency in future.

In all of these challenges, FloEFD supports battenfeld-cincinnati's development engineers early in the development process. Efficiency means savings of electricity and raw materials simultaneously.

References:

[1] www.battenfeld-cincinnati.com
[2] www.bluecompetence.net
[3] https://www.youtube.com/watch?v=vef7MvrOvt4