Intelligent Software for Blown Film Production

Smart Trio for Film Production

The sustainability debate is not the only reason why the requirements for packaging films are becoming increasingly diverse. The film needs to have certain properties and reproducible quality. Windmöller & Hölscher (W&H) uses Ruby Gain to monitor process limits. The system is based on three elements.

Varex II blown film extrusion line with MDO. © W&H

The demands placed on plastic packaging are becoming increasingly stringent and multifaceted. Alongside the highest demands on film quality and packaging functionality, sustainability aspects must also be taken into consideration. In accordance with the "reduce-reuse-recycle" principle, a large number of innovative and sustainable films and film composites are currently being produced, each of which must be sampled and qualified very extensively throughout the entire process chain until it is finally used. The replacement of PET/PE composites with single-origin PE/PE laminates is just one example of this. For these new sustainable solutions to prevail and establish themselves on the market, consistently high film quality in production is particularly decisive, as is the initial qualification, which also applies across different production locations in an increasing number of cases.

When Automation and Intelligence Go Hand in Hand

Whereas plastic machine manufacturing has consistently developed and introduced new technical solutions for increasing quality, output and resource efficiency in the past, the new solutions focus on a targeted combination of process automation and data intelligence to enhance the full potential of modern extrusion lines. As one of the first providers of extrusion lines, W&H created a system for recording, long-term storage and visualization of process data for all machines connected to the system in the 1990s using Information System Production (ISP). This system for retrospective analysis of the data, for instance, in the event of a complaint, has now become an important instrument for many manufacturers.

Although the collection, storage and navigation of the process data is thus fulfilled as a basic prerequisite for additional data intelligence, correctly interpreting the collected data still remains a challenge: Which machine settings are the right ones for achieving the required product properties? Which deviations from the required characteristic values are tolerable for a particular film product? Only a small group of process engineering experts has this knowledge. On the other hand, machine operators face the daily challenge of mastering hundreds of relevant material and process parameters on the production machines – usually in 3-shift operation. This process is supported by recipe management, work instructions and random quality checks in the laboratory.

Based on many years of experience with the ISP system, W&H has developed a system with the digital product "Ruby Gain" which combines the product knowledge and process data of extrusion lines and provides help which safeguards quality by interpreting the data. The product allows you to learn from previous production and monitor product-specific quality-related machine parameters in real time. For one, this supports consistently high film quality and avoids complaints. It also creates an important basis for product-related data transparency, which will be essential in the future when recycled materials are being processed.

Fig. 1. Film structure of a MDO-PE 5-layer film. The height of the bar represents the thickness of the layers, the color of the bar represents the different raw materials, and the width of the bar represents the proportion of the raw material in the respective layer. Source: W&H; graphic: © Hanser

Keep the Parameters in the Required Process Window

In addition to the raw materials that are used, the settings of the film extrusion line – ranging from the temperature in the extruders and the die head to the air ring and cooling air or chill roll settings to the web tensions in the winder – have a huge influence on the resulting film properties. Variations in the resulting process parameters such as the feed rates, the melt temperatures and the film bubble itself also have a decisive influence on the film properties. This is why it is essential to keep the parameters that influence the quality of each individual film product within a product-specific process window during production.

Because of the wide range of different film products in a production operation on the one hand and the multitude of relevant parameters on the other, it is unrealistic to define all parameter limits manually. It is also almost impossible for a machine operator to continuously monitor all process parameters. With Ruby Gain, it has been possible to ensure that the parameter limits of each individual film product are continuously monitored. Ruby Gain is based on three main elements:

- intelligent film product detection,
- automatic calculation of parameter limits, and
- monitoring of the correct parameter limits during production.

Product Recognition Using Fuzzy Logic

As described above, the process windows of different film products sometimes differ considerably from each other. For this reason, the first step is to differentiate between different film products in an automated manner, but also to group similar film products together. Roughly speaking, a film product is a film with certain properties which can be sold to end customers. It is typically produced in several geometries, i.e. different thicknesses and widths, as well as in different designs.

The film structure (**Fig. 1**), i.e. the quantity and thickness of the layers, the raw material used and its proportions, plays a decisive part in achieving the required product properties. To begin with, Ruby Gain determines all of the film structures which have been produced so far from the collected process data for the film extrusion line. Then, using a fuzzy approach, the similarity between the film structures is determined and these are subsequently grouped into products. Exchangeable raw materials and tolerances in the raw material proportions are also taken into consideration when doing this. Once Ruby Gain has been trained on the product portfolio, the product that is currently being produced is recognized during production and the list of recognized products is also extended.

Calculating Parameter Limits

The parameters which influence the quality should be monitored in the machine for each of the detected film products. Parameters such as extruder temperatures and the cooling air influence the melting and cooling process, while the melt pressure and the height of the frost line, for example, are indicators for the course of these processes. In other words, all these parameters define the process window that leads to the required film properties. In this respect, it makes sense not just to keep »

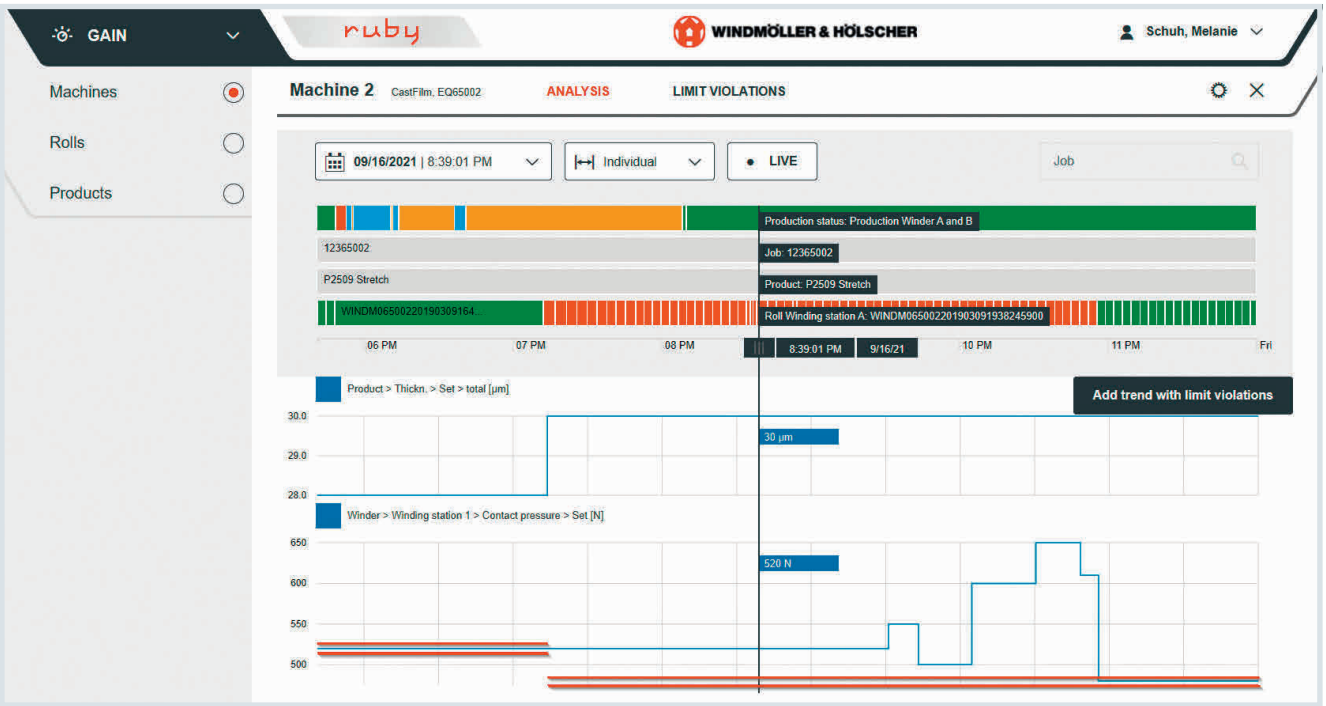

Fig. 2. The limit violation shows that the contact pressure still needs to be adjusted. © W&H

an eye on the 2-sigma value of the thickness deviation and the film width tolerance during production, as is currently customary, but also to define and monitor parameter limits for various other important target and actual values along the extrusion process.

The previous production of each individual film product with different geometries is thus analyzed and parameter limits are calculated for these parameters. Parameter limits therefore represent typical ranges within which the parameters were located during good-quality production.

During production, film products are recognized on the basis of the film structure, and adherence to the associated parameter limits is monitored. In the event of deviations, the machine operator is informed via the central HMI on the machine so that they can respond immediately. All sequences and deviations are also saved in Ruby Gain so that subsequent analysis or a search for the cause of quality problems can be carried out (**Fig. 2**).

An example which frequently occurs in practice is a changeover process in which the adaptation of winder parameters for the new product is essential. Here there is a risk that the adjustment – the contact pressure in this example – is forgotten among a large number of parameters that need to be changed.

Ruby Gain recognizes that a changeover has taken place on the basis of the film structure and the geometry of the film, and monitors the parameter limits of the product on the basis of the settings from previous production. As a result, settings which deviate from the pre-production settings are detected immediately, and the machine operator is informed. In this case, the contact pressure can be corrected immediately, and erroneous production can therefore be avoided.

In addition to erroneous operation, there are other causes for leaving the permissible process window and resulting deviations in the film properties or quality problems that occur, of course. If, for example, the pressure limits in the filtration must not be exceeded with certain products, Ruby Gain provides notification of a non-permissible pressure build-up at an early stage – long before a machine alarm would occur.

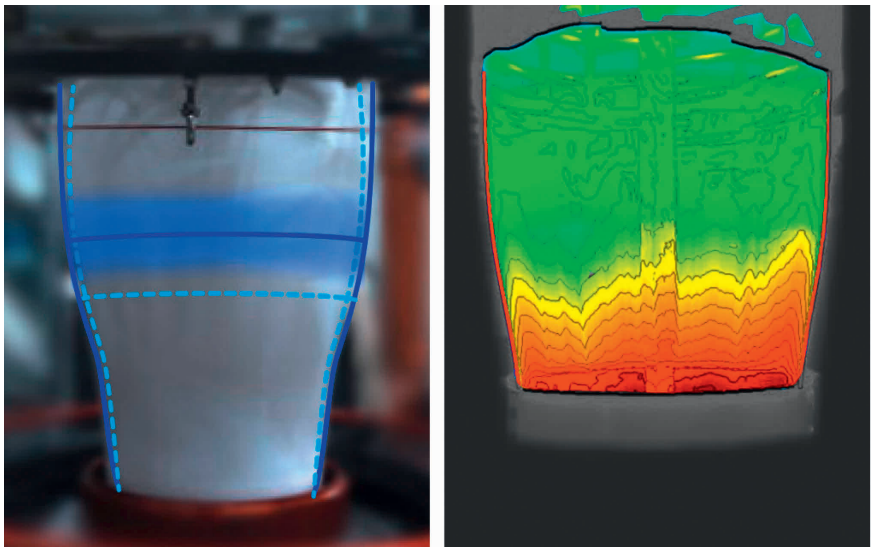

Fig. 3. Inline recording of the cooling behavior in the film bubble. The setpoints for the bubble shape and the frost line height are represented by broken lines, and the current values by continuous lines. © W&H

If all parameters lie within the valid parameter limits for the product that is currently being produced, this is an indication that the film being produced will have the required film properties. However, if unexpected deviations occur, a quick reaction is essential to directly avoid scrap and avoid running the risk of very expensive subsequent process steps. However, monitoring the parameter limits is useful not just during active production, but particularly also after startup or changeover processes. The information about when marketable film will be produced again is of fundamental importance when it comes to reducing start-up and conversion waste.

Summary and Outlook

The operation and automation of extrusion lines is under constant development to master complex processes and increasing quality demands from further processing so that the operator can be provided with the best possible support. The integration of additional components for increasing plant efficiency and quality consistency will continue, e.g. using fully automated air rings, intelligent monitoring of the film bubble or assistance systems for startup and product change processes (**Fig. 3**). This progressive development means that the consistent collection of data is already an indispensable future investment, and represents the basis for full transparency in the value creation chain and the unlocking of further optimization potential. The automated interpretation of this data by means of intelligent linking of product and process information in particular is already creating a considerable amount of added value in production. If this data is also enriched with information from the laboratory in the future, the loop can be closed and the automated learning of correlations between the product, the machine settings, the process parameters and the film properties can be made possible. ■

Info

Text

Dr.-Ing. Melanie Schuh works in the department product management for digital products at Windmöller und Hölscher KG in Lengerich, Germany;
melanie.schuh@wuh-group.com
www.wh.group

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