

Defined Stretching

MDO Technology. A high-performance stretch roll stack for manufacturing monoaxially oriented polymer film has been developed using a technology tailored to the film material, film properties and application. It produces film with high transparency and good mechanical, optical and barrier properties.

The technique of stretching plastic film in a downstream process has long been used to selectively improve the physical properties. The main properties concerned are strength, elastic modulus, ultimate elongation, tear strength, stiffness, transparency, gloss, density and barrier properties. This process started to gain large-scale industrial importance in the 1970s, as cellophane and cellulose acetate were replaced with biaxially stretched PP or PET film. Uniaxially stretched flexible film of PP and PE have also long been used as breathable hygienic films, stretch films and tape applications.

Optimised Film Properties by Orientation

Monoaxial stretching in the machine direction (machine direction orientation, or MDO for short) has long been carried out on roll systems. For semicrystalline polymers such as PE and PP, the stretching process is carried out just below the melting range. The morphology of the polymer is changed significantly (orien-

tation of the crystallites and molecular chains, breaking open of crystal structures [lamellae, spherulites], denser packing). This results in a higher density, better barrier properties and more favourable mechanical and optical film properties. The property changes caused by the stretching process are very sensitive to the process conditions (particularly degree of stretching, stretching rate and temperature) and their control.

The stretch rolls have until now been designed for layflat widths of maximum 2000 mm, which limits the cost effectiveness of the downstream processes (e.g. two-up printing). The machine performance and constancy of the stretched film are also not good enough to offer an economic alternative to established film applications. In developing a new stretching roll system, Kiefel Extrusion GmbH of Worms/Germany now wants to open

up new applications for this process in the field of thin packaging films and specialty films.

Precise Speed and Annealing

To manufacture monoaxially stretched monolayer and laminated films with defined, reproducible properties the process parameters must be precisely maintained and variable within wide limits. This makes high demands on the automation and control technology. Kiefel has taken a new direction with its stretch roll unit for MDO technology. The system, unveiled in June at NPE in Chicago under the name Kirion MDO (Fig. 1) – like traditional stretch roll systems – consists of four components:

- heating zone,
- stretching station,
- annealing station, and
- cooling zone.

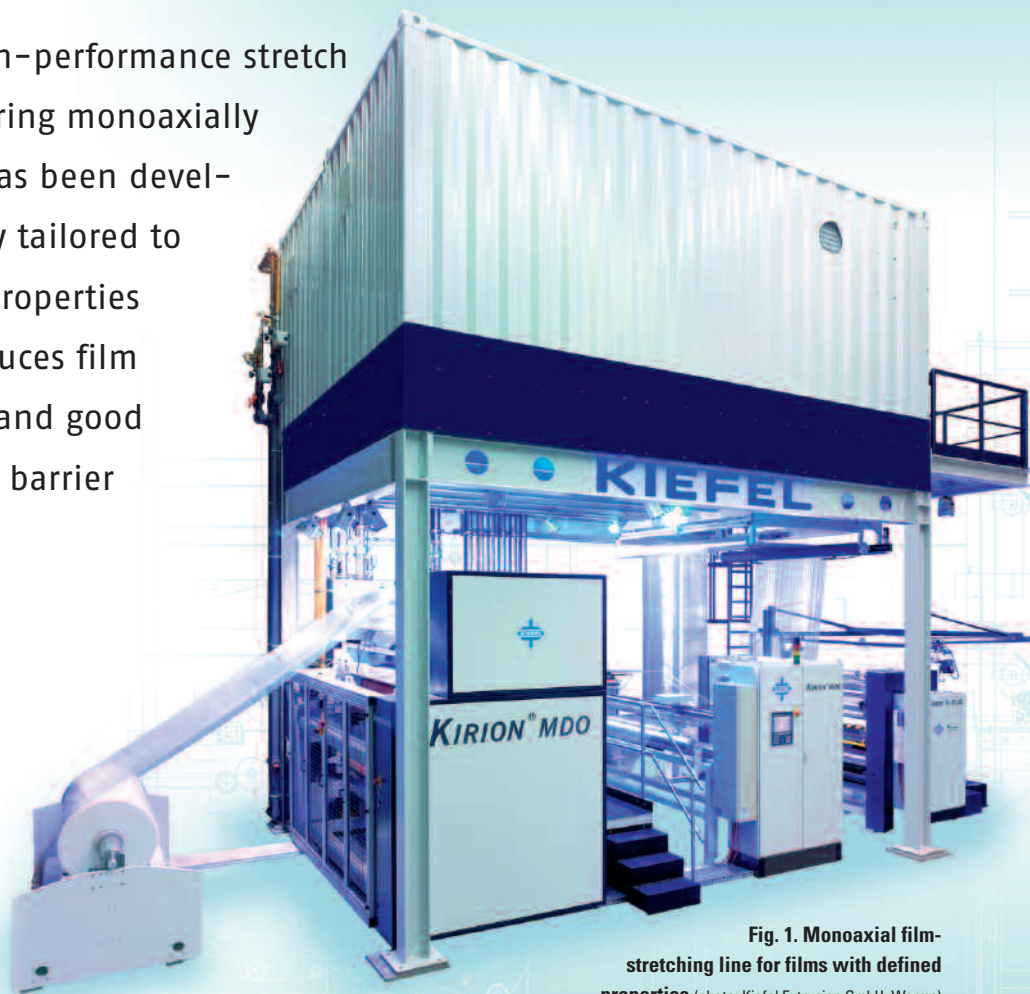


Fig. 1. Monoaxial film-stretching line for films with defined properties (photo: Kiefel Extrusion GmbH, Worms)

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All the heating, stretching and cooling rolls are driven by separate servomotors and temperature-controlled by means of separate heating/cooling units. This individual control of roll speed and temperature is the prerequisite for a reproducible, tailored property profile (film thickness, orientation, mechanical and optical properties etc.) of the MDO films. Furthermore, the roll arrangement with the pressure rollers and lay-on rollers

touch-screen monitor (Fig. 3). The control unit also stores formulation data, alarm management and quality trend displays. Since the film contracts at the edge during stretching, thickness differences occur at the edges across the film width. These are recorded by capacitive thickness measurement, so that defined edge trimming can be carried out to obtain films with uniform thickness. The unwinding and winding rollers permit

own film production can process and enhance films.

The most important economic advantages of the MDO line are:

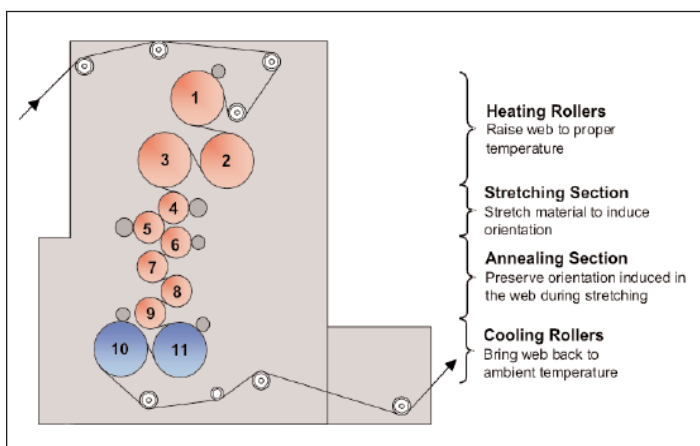
- various installed sizes with layflat film widths up to 2600 mm,
- throughput rate of the line up to 1000 kg/h,
- film speed up to 300 m/min,
- lower investment costs compared with conventional casting or laminating lines.

With laminated films, barrier layer thicknesses with a minimum thickness of 0.5 µm can be achieved. The corresponding MDO films are characterised by

- constant film thickness,
- improved mechanical properties, such as stiffness, toughness, tear strength etc.,
- improved optical properties, such as gloss and transparency,
- higher gas and water vapour barrier, meaning that EVOH or PA layer thicknesses in laminated films can be reduced, which in turn leads to a
- reduction in raw materials costs.

Thus, defined stretching of PP blown films, for example, can produce transparent, flexible thin film, which can otherwise only be manufactured by the much more expensive casting process. In composite films with barrier layers, the orientation effects a significantly higher barrier effect, so that, e.g., a barrier layer thickness of 1.5 µm EVOH in an MDO film has the same barrier effect as a 6 µm-

Fig. 2. Roller configuration; 1 to 3: heating rollers, 4, 5: stretching rollers, 6 to 9: annealing rollers, 10, 11: cooling rollers



(Fig. 2) permits high production speeds without air cushions forming between the film and roll surface.

In the heating station (three rolls with 400 mm diameter), the produced films with widths up to 2600 mm are heated to the desired stretching temperature; the large roller diameter ensures a large contact area and good heat transfer (temperature accuracy $\pm 0.5^\circ\text{C}$). The actual stretching process takes place in the roll nip between the two stretching rolls, which rotate at different speeds (roll diameter 250 mm). The silicone-coated pressure rolls ensure adequate traction and prevent slip. The stretching gap has a length of no more than 200 mm. The degree of stretching can be set freely between 1:1 and 1:10 (depending on the material combination, temperature and the desired property profile of the MDO film, in particular the film thickness). The desired film properties (degree of stretching, film thickness, morphology etc.) are fixed in the downstream annealing station (four annealing rollers with 250 mm diameter), and inherent stresses are smoothed out at the same time. Two cooling rolls with diameters of 400 mm bring about the cooling of the films to ambient temperatures. The maximum output rate of the system is given as 1000 kg/h, and the highest film speed as 300 m/min.

The process parameters are entered into the machine control (Kirion C) via a

film rolls with maximum 1200 mm diameter.

The MDO line can be operated either as an inline unit together with a blown film or cast film line or else together with unwinding and winding rollers, as an off-line film enhancement system for all types of plastic film. Inline operation is economical for large order volumes. This



Fig. 3. Centralised touch-screen monitor of the control unit

allows savings in personnel costs and optimisation of the machine footprints. However, the production rates of the film line and stretch roll system must be matched to one another (max. 300 m/min in the case of the MDO line). Offline operation allows the film extruder higher flexibility with frequent product exchange. However, with an MDO line, even a processor without his

thick EVOH layer in a conventional composite film. There is hardly any other way of producing such thin barrier layers so economically.

New Market Opportunities for Film Processors

Controlled monoaxial stretching of films and laminated films greatly improves the

properties of products. Relatively thin films with better mechanical and optical properties and better gas and water-vapour barrier properties first and foremost mean weight and cost savings. Thus, blown or cast films can be tailored to a particular application in an ancillary process.

In the course of process optimisation, Kiefel involved raw materials manufacturers in the early stages of development. It was found that, in the MDO process, polyethylenes with bimodal molecular weight distribution are suitable for producing thin films with high transparency, tear strength, toughness and stiffness together with a good barrier effect.

Besides the traditional fields of application for monoaxially stretched plastic films of all kinds, the typical properties of MDO films also make them suitable



Fig. 4. Food packaging with MDO film

for other applications, such as thin-walled laminated films for

- food packaging,
- flat-bottom bags,
- label films,

- shrink labels, and
- breathable hygiene films.

There are good economic reasons for this (reduction of film thickness with comparable product properties, replacement of more expensive materials). Fig. 4 shows a food package as example. It is based on a 150 µm-thick 5-layer blown film (PE-LLD/adhesion promoter/EVOH/adhesion promoter/PE-LLD) with an 18 µm-thick EVOH layer. After roll stretching, a 37.5 µm-thick laminated film is obtained with the EVOH layer reduced to 4.6 µm thickness with no loss in barrier effect. This example shows the economic advantages that are possible with roll-stretched films. MDO technology could thus change the market for flexible thin films in many applications. ■

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