



100%
eXtrusion
SHEET LINES

PP / PS / BARRIER
THERMOFORMING SHEET

LINES FOR THERMOFORMABLE SHEET



INTRODUCTION

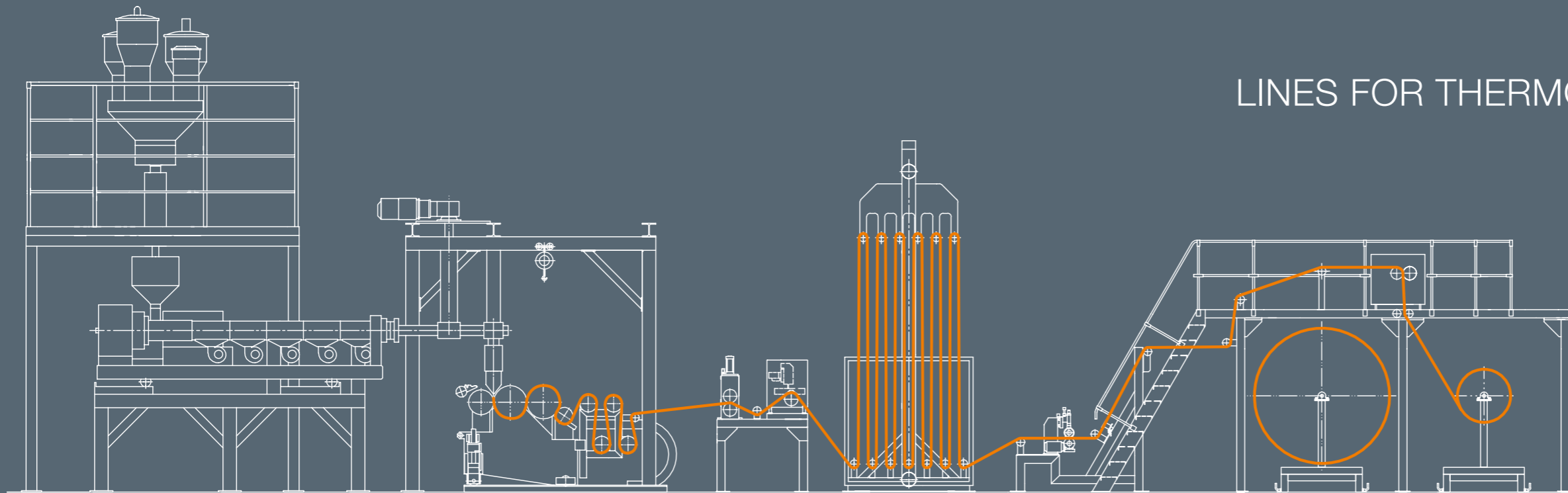
According to the United Nations, food production must nearly double by 2050 in order to feed the expected global population of more than 9 billion people. Sadly, a third of the current worldwide output is wasted. Therefore, one of the key targets is to increase food storage life and minimize losses during shipment. Small service packing units will also serve to further reduce spoilage at the customer. As a consequence, food and consumer goods packaging growth will continue to be disproportionate for some time to come.

Containers produced using the thermoforming process constitute a significant portion of overall packaging material consumption. These containers are manufactured from extruded sheet and this brochure contains SML's solutions for the production of sheet for thermoforming applications. Business success depends upon optimized sheet quality and low production costs. And while modern, **high-performance extrusion lines** offer top efficiency, a lot of smaller lines are still required for general purposes and higher flexibility.

High efficiency is defined as affordable investment cost in combination with reduced energy consumption, a low operator requirement and minimized service expenditure. SML's **high-performance extrusion lines** are designed to provide just this mix. Of even greater importance in this equation is the efficient use of polymers, which very often constitute over 90 per cent of the finished product cost. SML lines provide special features to cut polymer wastage, such as extremely tight gauge tolerances and minimised start-up losses.

Moreover, SML's superior foamed sheet production technology is a response to the trend towards a reduction in packaging weight. Depending on the design of the containers and the thermoforming tools within the thermoforming process the skeleton can represent up to 50 per cent of the initial sheet volume. In fact, SML extruders are designed specifically to process a large quantity of regrind from thermoforming.

The production of sheet for thermoforming does not represent a separate value chain, but instead is very closely linked to the thermoforming process. Accordingly, one high-performance SML sheet line can feed several thermoformers and this is why no compromises are made with regard to product reliability. In fact, SML extrusion lines are designed for **24/7 production reliability** and a long service life. SML's company's complete internal product documentation enables it to provide support throughout the entire lifetime of a line.



LINES FOR THERMOFORMABLE SHEET

CONTENTS

High-Performance Class Sheet Lines	6
Economy Class Sheet Lines	8
Barrier Sheet Lines	10
Inline Extrusion Lines	12
Line Description	16
Extrusion Unit	18
Downstream Equipment	25
Winding Systems	28





HIGH-PERFORMANCE CLASS SHEET LINES

Producing commodities in tough competition is a genuine challenge. Under these circumstances, modern **SML high-performance class sheet lines** offer the best chances for success. These lines provide extremely high output levels of sheet production in combination with top quality and low energy consumption.

Indeed, owing to their HSE's (high-speed extruder), their high-performance calendaring rolls and an ideal number of post-cooling rolls, they can outperform other relatively modern systems by a factor of 2 to 4. All SML high-performance sheet lines utilize a horizontal roll stack.

TARGETS:

- Maximum output and line speed
- Energy efficiency
- Polymer savings



high performance line for PP/PS

PERFORMANCE LEVEL:

Polymer	production performance (at 1m sheet width)
PS	up to 3,300 kg/h
PP	up to 3,000 kg/h
PET	up to 1,800 kg/h

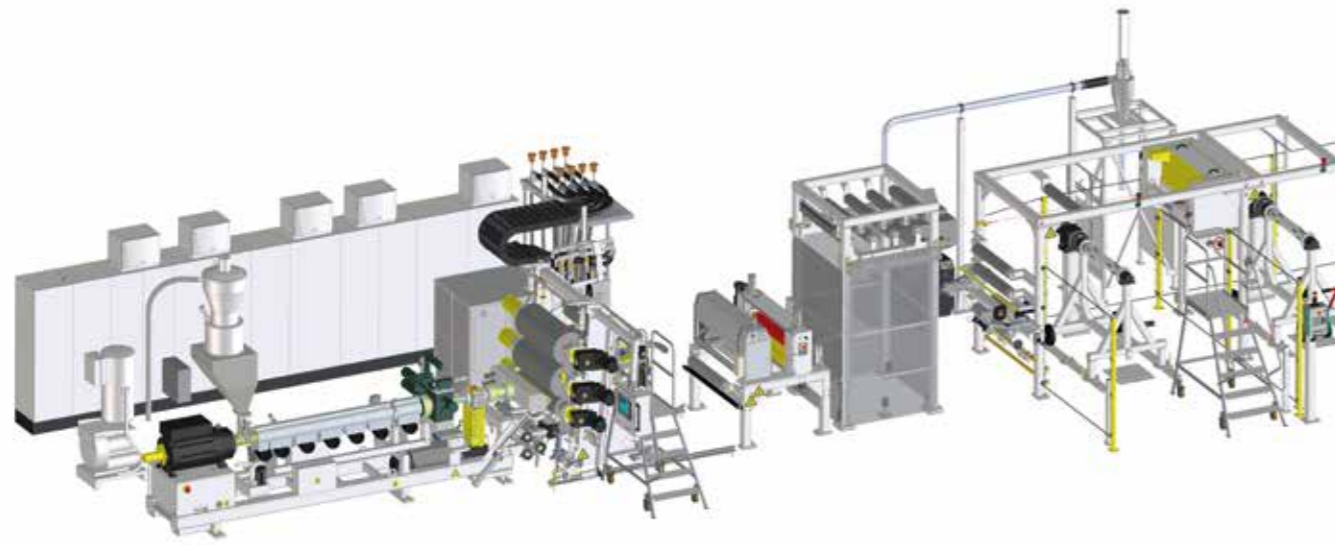
CONFIGURATION EXAMPLES:

	TSL-1 Jumbo	TSL-2 Jumbo
Extruder	1x HSE75	3x HSE75
Plastification performance	PS: 1,500 kg/h PP: 1,350 kg/h	PS: 3,300 kg/h PP: 2,700 kg/h
Sheet thickness range	200 - 2,500µm (thin PP films may require an air knife)	
Number of layers	1	3
Sheet width	1,000mm	1,200mm
Line speed limit	70 m/min	
Webs	1	2
Winding diameter on 6-inch shafts	2,000mm	2,000mm

SPECIFIC ATTRIBUTES:

- Modular design
- High-speed extruders
- Easily handled feedblock technology
- Standard 1-3 layers
- Horizontal roll stack (with multiple nips)
- Quick ramp-up function
- Optional air knife





ECONOMY CLASS SHEET LINES

For smaller output requirements, SML has launched its economy class sheet lines. These use a vertical roll stack, which allows the extruders to be placed directly on the floor. Therefore, the lines not only have a simpler design, but can also be installed in buildings with lower ceilings.

The central units of the lines are the HSE-extruder and the high-performance calendering rolls, which enable the production of SML quality sheet with an extremely reasonable price-performance ratio.

TARGETS:

- Medium output and line speeds
- The provision of an interesting alternative for simpler applications
- Energy and polymer savings



HSE extruder module for vertical roll stack extrusion lines

CONFIGURATION EXAMPLES:

	TSL-Eco Jumbo
Extruder	1x HSE75
Plastification performance	PS: 1,100 kg/h; PP: 900 kg/h
No. of layers	1
Sheet thickness range	200-2,500µm (thin PP films may require an air knife)
Net sheet width	1,000mm
Line speed limit	40 m/min
Webs	1
Winding diameter on 6-inch shafts	2,000mm
Options	Co-extruder and feedblock Air knife Gauge Cantilever winder



SPECIFIC ATTRIBUTES:

- Modular design for 1 to 5 layers
- Main extruder, pump, die and electrical cabinets on one frame
- Vertical roll stack, 1,200mm roll width
- One control panel on the roll stack



BARRIER SHEET LINES

Extended shelf life, the replacement of glass for containers for fruit products, and spreading of pre-cooked meals demand first class packaging barrier properties. As a consequence, barrier sheet production shows a worldwide growth.

SML's extrusion lines for barrier film and sheet are based on the company's vast experience and therefore represent one of its major strengths.

Our engineers plan barrier line projects professionally, using their expertise with regard to the choice of co-extrusion equipment, correct polymer treatment, rapid line start-up and product optimization.



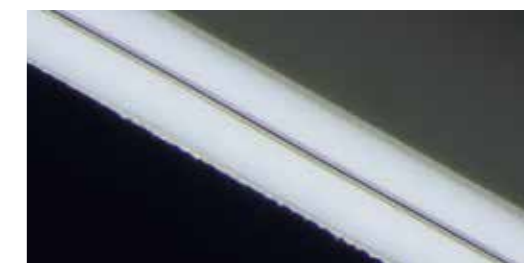
extruder
arrangement of a
barrier sheet line

TARGETS:

- Finest sheet quality, no problems after thermoforming
- Energy and polymer savings
- Tight and safe layer distribution
- Minimal multi-layer waste
- Skeleton reprocessing
- Outstanding polymer flow design to avoid polymer degradation effects

ATTRIBUTES:

- Customized design
- Layer security: individual extruders for each layer, gravimetric output control
- Flexible feedback technology: 5L/7L/9L or more with layer configuration and layer distribution manipulation
- HO-LT extruder technology
- Optional edge encapsulation for barrier polymers
- Horizontal roll stack, customized sheet widths



EVOH barrier sheet



I-TF3 inline compact extrusion system with HSE90

INLINE EXTRUSION AND THERMOFORMING CONSTITUTE THE MOST EFFICIENT METHOD OF PRODUCING LARGE QUANTITIES OF CUPS AND CONTAINERS

Sheet extrusion and the subsequent conversion into thermoformed articles represent well-established methods in the plastics industry. Until recently, these two production phases were generally separated, since thermoformers were running at low throughput, being unable to absorb the complete output from an extrusion line.



However, the situation has changed in recent years. Now high-performance thermoformers are available on the market, which can process a respectable amount of sheet per hour. Various cups, containers and trays are produced in huge lots and some can even process the total sheet production of a line.

Under these circumstances, inline extrusion and container thermoforming offer significant **advantages**. For example, a **closed loop material flow** means that only thermoformed containers leave the production line. There is no edge trim and, with direct skeletal refeed, neither storage silos for recycle, nor recycle reuse management are required.

Furthermore, intermediate roll storage and transport, as well as winding and unwinding technology become unnecessary.



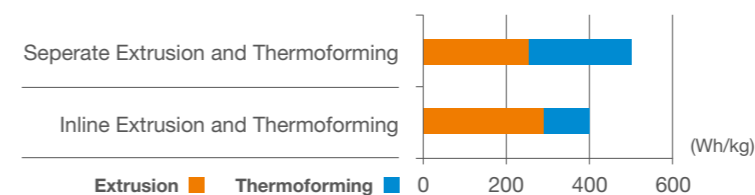
I-TF3 in operation with thermoformer

Greater energy efficiency means that savings of 20-25% are possible. The sheet is not cooled down more than necessary and a great deal of heat is retained in its center. It is therefore much easier to reheat the sheet to thermoforming temperature and less heating energy is needed.

As far as quality is concerned, conventional thermoforming demands that far more heat is transferred into the sheet before thermoforming. The surface of the sheet must be hotter in order to transfer the heat to the center and with crystallizing polymers, such as PP, the morphology changes on the surface require that the forming temperature be raised even further. By contrast, inline sheet can be formed at lower temperatures and better heat distribution results in superior final product clarity and stiffness.



ENERGY SAVING POTENTIAL OF INLINE EXTRUSION AND THERMOFORMING:





TSL-ECO Jumbo

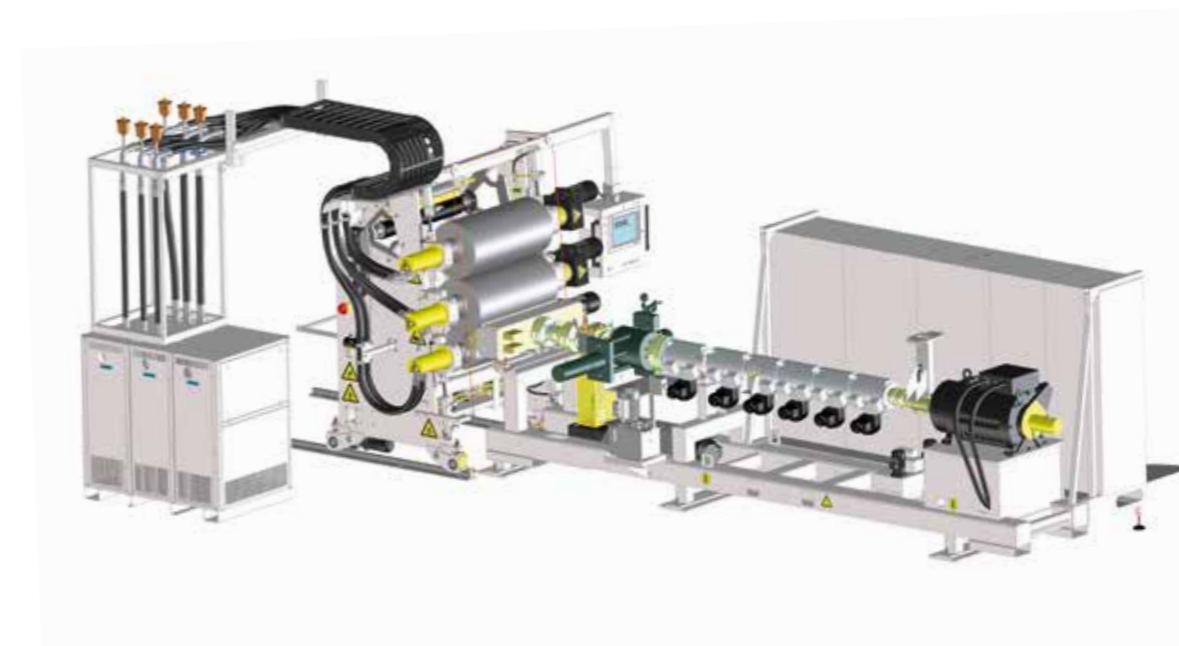
In addition, the effect of extrusion settings can be seen on the product immediately and counter-action can be initiated, if required. In the case of off-line production such defects might be hidden in the sheet, which occasionally creates unforeseen problems during subsequent thermoforming.

SML has designed a brand new series of sheet lines for inline thermoforming applications with key features that include economic pricing, compact modules, quick commissioning and suitability for a tropical environment.

No compromises have been made with regard to the functional components and extremely uniform sheet formats and temperatures are achieved using the SPG roll, Thin Shell roll technology, a 5°-inclined roll stack, and analogue valves for roll temperature control.

STRENGTH OF CONVENTIONAL SHEET LINES (TSL) AND INLINE SYSTEMS (I-TF)

	TSL	I-TF	
Very high output	+		Thermoformer speed limit
Wide product range - flexibility	+		
Frequent product changes	+		
Cup transparency and stiffness		+	
Energy efficiency		+	Best with warm scrap re-feed
Efficient use of polymer		+	No edge trims
Scrap material and finished roll management		+	
Operator requirement		+	
Payback for multilayer lines	+		
Space requirement		+	



I-TF3

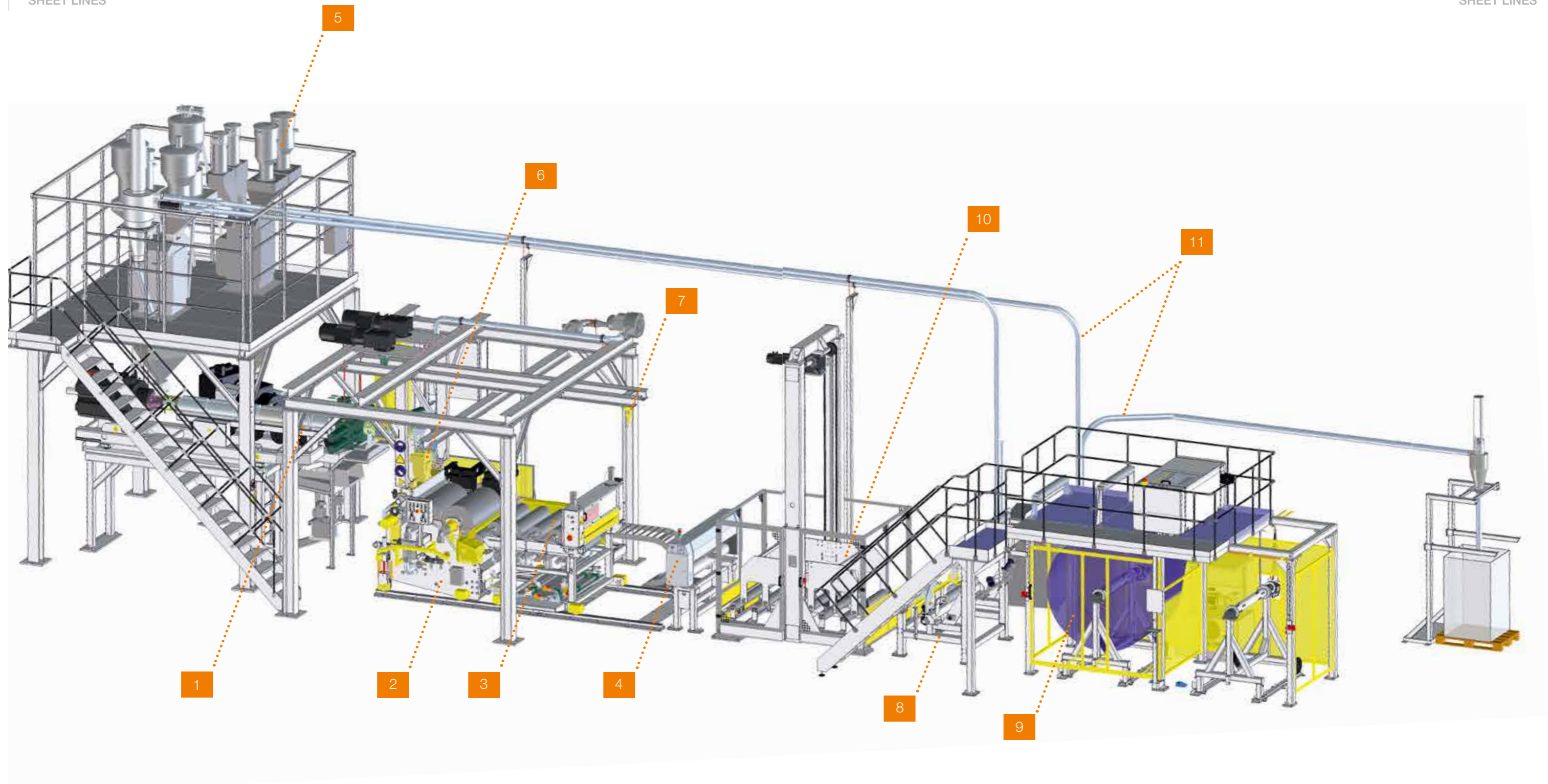
LINE CONFIGURATION:

	I-TF2	I-TF3
Extruder	HSE75	HSE75 (*)
Plastification performance	PS: 700 kg/h PP: 600 kg/h	PS: 1,100 kg/h PP: 900 kg/h
Co-extruder option	ES35 or ES35 HO-LT	
Maximal sheet width	920mm	920mm
No. of layers	1	1
Roll stack	Ø SPG300/400/400mm	SPG300/490/490mm
Roll width	1,050mm	1,050mm
Post cooling rolls (optional)	3 x 250mm	

(*) As an alternative, the HSE90 can be used for more polymer flexibility



optional post cooling rolls (retrofitable)



- | | | | | | |
|---|---------------------------|---|---|----|--------------------------|
| 1 | HIGH SPEED EXTRUDER (HSE) | 5 | GRAVIMETRIC BATCH FEEDING AND DOSING SYSTEM | 9 | A-FRAME WINDER |
| 2 | TRIPLE GAP ROLL STACK | 6 | TOOL UNIT | 10 | ACCUMULATOR |
| 3 | POST COOLING ROLLS | 7 | TOOL UNIT WITH CHAIN HOIST | 11 | REGRIND CONVEYING SYSTEM |
| 4 | GAUGING SYSTEM | 8 | EDGE TRIMMING | | |



standard extruder



HO-LT extruder

EXTRUDERS

STANDARD SINGLE-SCREW EXTRUDER

SML has a wide range of standard extruders with screw diameters that currently start at 35mm and end with 220mm. All the extruders have shown to work successfully with sheet applications involving closed barrel and vented variations. SML standard extruders use a direct motor-gearbox combination instead of energy-consuming belt drives.

HIGH SPEED EXTRUDER

SML was one of the first companies to successfully integrate HSE extrusion into its film and sheet lines. For sheet applications, it has solutions for 75mm and 90mm screw diameters and both extruder sizes cover the same output range. The 75mm extruder runs at a higher screw speed and with superior energy efficiency, while the 90mm extruder is selected when a wider range of different polymers is processed.

The output of these extruders is determined by screw speed, motor size, L/D ratio and screw design. SML covers a wide range of outputs with one screw diameter, but differing extruder configurations. Naturally, all HSE extruders are able to handle extended recycle rates and are equipped with vented screws and barrels.

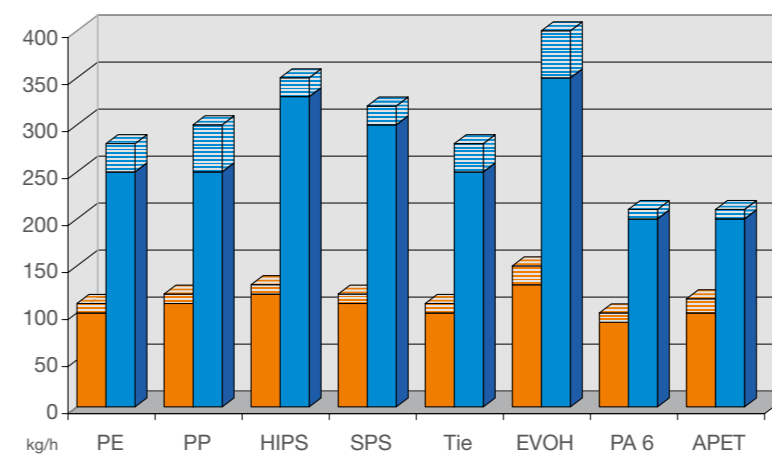


HO-LT EXTRUDER

HO-LT stands for “High Output - Low Temperature”. The special screw and barrel configuration enables these machines to plasticize a huge amount of polymer at relatively low screw speeds. The result is an extremely low melt temperature, extremely stable output and high pressure generation with very fast material changeover time. These features mean that this

extruder does not require a melt pump. HO-LT extruders are ideal for heat sensitive polymers such as EVOH and adhesives. SML employs them for these types of polymers and for the thin functional layers in co-extruded products.

typical output rates for Ø35 and Ø55 HO-LT Extruder



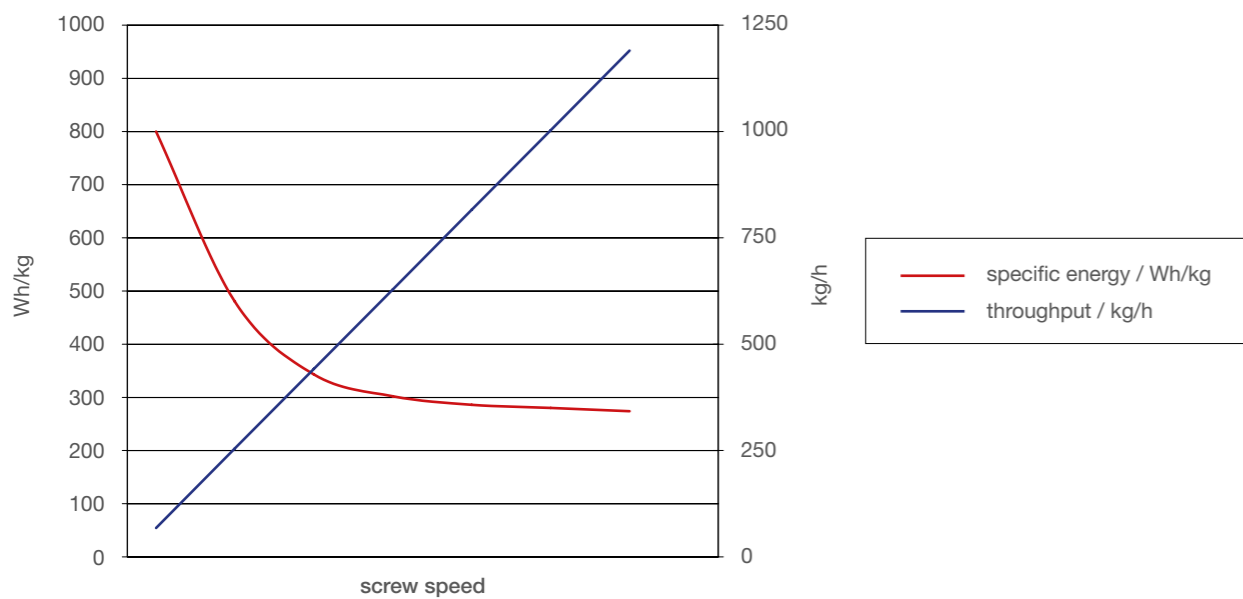


extruder with energy efficient torque motor

ENERGY EFFICIENCY

Extrusion lines with HSE extruders provide excellent energy efficiency. Indeed, the faster they run, the more economical they are. Well over 50 per cent of the energy required for a sheet line is consumed by the extruder motor(s). SML extruders only use brushless motors with a high degree of efficiency and their AC motors either adhere to the IE2 standard or are even better.

Extruders with a direct connection between the motor and the screw are most efficient, as the gearbox is omitted. These motors can be of a special AC or torque type. Some of SML's extremely energy-efficient HSE extruders employ this technology.



regrind material

USE OF REGRIND MATERIAL

Apart from start-up scrap, the continuous production of sheet generates edge trim. In addition, in-house thermoforming can generate up to 50 per cent waste from the skeleton. SML sheet extruders are designed to process a very high volume of regrind material and for some applications even 100 per cent is possible. This is possible because the company's modern screw geometries are very forgiving with regard to changes of regrind density. Refeed of scrap can be done directly, from buffer storage or using standard dosing equipment.

VENTING

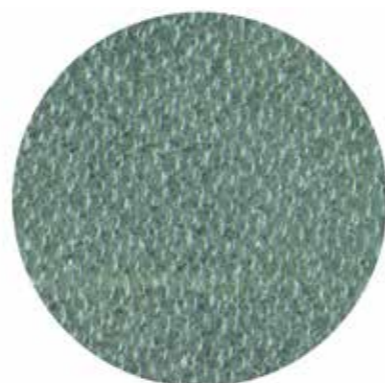
The use of vented extruders is very popular for sheet extrusion and quite often it is sufficient to vent atmospherically. In addition, a wide choice of active vacuum systems is available. All vented barrels, employed in thermoforming extrusion, can be plugged (e.g. for the use of foam).



gas injection

FOAM

Polymer foam can be produced using additives (chemical), direct gas injection (physical), or a combination of both. A special screw and a gas dosing pump are required for the physical foaming process. The gas injection process is less expensive than the use of additives and the direct gas injection allows quick adjustment to the required density in less than 5 minutes.



foam structure in the microscope

TOOL UNIT

The SML tool unit integrates high quality components from highly reputable manufacturers. The appropriate technology for the specific requirement is selected, but sufficient flexibility remains for the accommodation of customer preferences.



melt filtration

MELT FILTRATION

The output, the polymer, the required filter mesh and the anticipated amount of contamination define the size and type of the filter. Single- and double-piston concepts are frequently used for thermoforming sheet. These are manually actuated (for small units) or hydraulically actuated, and double-piston systems allow screen changing while the machine continues running.

MELT PUMPS

Melt pumps operate as a volumetric dosing system for the melt and also build-up pressure efficiently. The constant volumetric flow ensures the perfect length tolerance of the sheet and naturally contributes to the stability of the sensitive melt bank between the calendaring rolls. An excellent pressure build-up capability relieves the screw of this task, which makes it easier to operate vented extruders economically. In addition, the melt pump can compensate a certain degree of extruder instability, originating from a very high level of low-density regrind.



STATIC MIXERS

Static mixers are generally used to improve the temperature homogeneity of the melt, which, if uniform, supports consistent quality across the width of the sheet.



flat die

FEEDBLOCKS AND DIES

A number of solutions for feedblocks are available, which range from simple fixed geometry inserts, to flexible solutions for layer configuration, adaptable flow geometry, and elements for the fine tuning of the traverse layer distribution. The higher technology level is frequently used for barrier sheet lines.



The focus, with regard to sheet dies, is on simplicity, robustness and the ideal design of the flow geometry. As a rule, today's sheet dies do not need a restrictor bar and correct design allows die operation with only a flexible lip. A robust decking system complements this system.

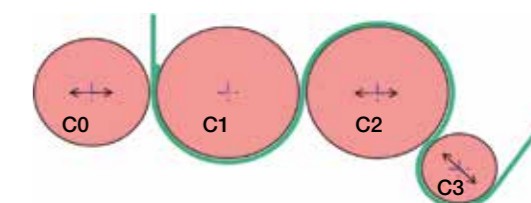


horizontal roll stack with additional cooling rolls

ROLL STACKS

The melt leaving the die must be formed and cooled, which generally involves a calendaring process that is performed with rolls, arranged in a stack. Its design and the relevant process settings define properties such as width, thickness, surface, transparency and flatness, and frequently, the mechanical properties of the sheet as well.

SML generally employs roll stacks with a horizontal roll arrangement in its high-performance sheet lines. This means, that the melt flow from the die to the rolls follows gravity, which avoids undesirable effects such as the melt touching one of the rolls prematurely. Moreover, the melt bank can be positioned on either roll, which allows maximum flexibility for the optimization of product quality.



SPECIFIC ATTRIBUTES:

- Thin shell rolls
- SPG roll
- 3rd gap
- Additional cooling rolls
- Air knife
- Temperature controlled unit (TCU) open or closed loop

horizontal
roll stack

The specially designed SPG (Smart-Parallel-Gap) C0 polishing roll ensures a parallel gap between the rolls, since it deflects exactly inverse to the C1 roll. The parallel gap provides a perfect sheet profile with minimal operator intervention. This principle works for a wide range of sheet width and nip pressures, allowing comfortable and quick changes of sheet gauge with minimal die adjustment.

Modern and safe Thin Shell Roll technologies allow higher cooling rates and better heat uniformity at the sheet edges. This results in higher production performance, less edge trim and better winding quality. In comparison to conventional rolls, Thin Shell Rolls do not require chilled water of a very low temperature level.

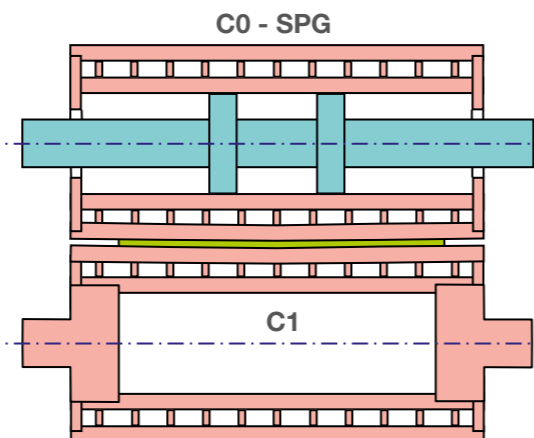
Additional cooling rolls can be installed without compromising the process or the handling of the machine. Free access to the bolts of the hanging die provides maximum comfort and allows the easy integration of a die splitting device.

For handling and process-flexibility reasons, the use of horizontal roll stacks for multiple extruder installations, such as barrier sheet lines, is strongly recommended.

The typical roll dimensions for thermoforming sheet extrusion are diameters of 400-715mm and widths from 900-1,800mm, while other dimensions are available on request.

Vertical roll stacks are frequently used in the medium-performance sheet line range. The extruders can operate at a lower height, which allows favourably-priced solutions.

SML in-line extrusion systems use a new type of vertical roll stack with integrated pull roll.



vertical roll stack

GAUGING SYSTEM

In answer to the various regulations in customer countries and specific product needs, SML supplies different automatic gauging systems:

- Inductive / capacitive sensors
- Air caliper systems
- Radioactive Beta-ray sensors (Krypton 85 or Sr 90)
- X-ray sensors
- Laser shadow

All these systems are available for dies with manual adjustment or automatic profile control, and are equipped with a control for the speed of the main cooling roll C1, to maintain the average value of the thickness setting.

EDGE TRIM CUTTING/REMOVAL

Edge trims are cut off using static blades or motor-driven circular knives. A precise cut is required for excellent winding quality. The edge trim is usually pulled into an inline grinder and the regrind is then either filled into big-bags for interim storage or refeed directly to the main extruder via a conveying screw, mounted above the extruder inlet opening.

inline thickness measuring unit with
inductive/capative sensor



WINDING SYSTEMS

SML customers can select from a wide range of different semi- and fully-automatic sheet winding systems. Semi-automatic winders work in combination with an accumulator, which picks up the sheet during the manual change of the roll in the winder. All winders are designed and built by SML.

The accumulator works from a bottom to top position, while a torque-driven servo-motor generates storage movement and precise web tension.

- Film capacity: standard 38m, others possible on request
- Guide roll diameters of 120 and 160mm available
- Access doors at operation side for easy sheet feeding into the accumulator in the bottom position

SEMI-AUTOMATIC SHEET WINDERS

These winding systems are known for excellent production reliability at an attractive cost level. Semi-automatic winders in combination with an accumulator facilitate safe and easy roll changes by the operators.

SML offers different winding systems, depending on customer requirements and the available floor space.



WINDER W500 A-FRAME

This is a single- or multi-web winder with two A-frame winding trolleys for each web.

After the roll change procedure, an operator removes the A-frame trolley with the finished roll from the winder. The roll itself has to be lifted from the trolley by means of a crane or a forklift.

The winder W500 is a comfortable and economic solution for large roll diameters.



WINDER W600 CANTILEVER

This single- or multi-web, winder has two winding stations with winding shafts for each web supported on just one side.

After the roll change procedure, a manually operated lifting trolley is used to remove the finished roll from the cantilever shaft, which remains in the winder. This system ensures maximum operator convenience, especially in the case of small diameter rolls and frequent roll changes.

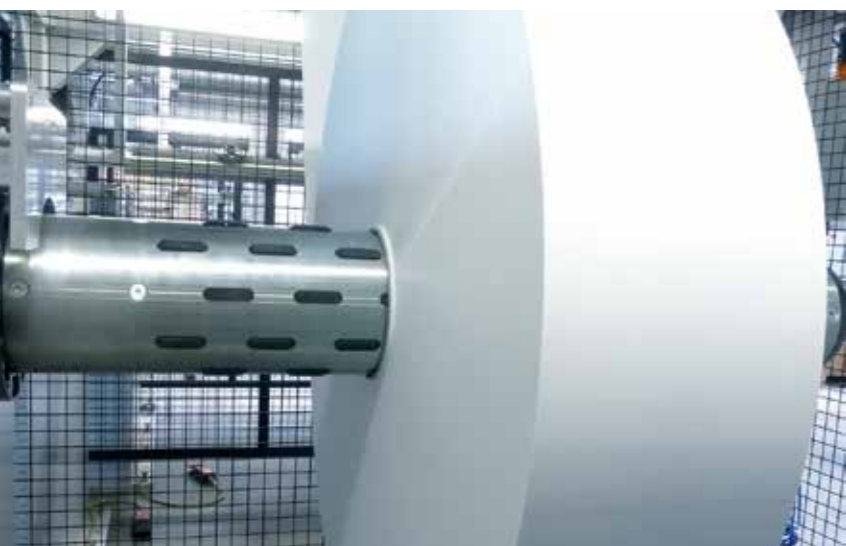


WINDER W550 COMBINED A-FRAME / CANTILEVER

This winder combines the advantages of the A-frame winder 500 and the cantilever winder W600. The A-frame winding trolley is typically used for making jumbo rolls, while the cantilever winding shaft is best suitable for making frequent roll changes when producing small rolls. So the winder W550 stands for increased flexibility and production reliability in making roll diameters from small to big.

The winder can be easily modified from an A-frame winder into a cantilever winder. The A-frame trolley only has to be moved out and the cantilever shaft is quickly fixed to the drive disc.





PS film



e-container

Winding	W500	W600	W550
Net film width max.	950mm / 1,100mm 1,300mm / 1,550mm 1,700mm / 1,900mm	650mm / 950mm 1,100mm / 1,300mm 1,550mm	950mm / 1,100mm 1,300mm / 1,550mm
Number of webs	up to 3	up to 3	up to 3
Core ID (inch)	3, 6, 8	3, 6, 8	3, 6, 8
Thickness range	150-1,600µm	150-1,200µm	150-1,600µm
Max. mech. speed	70 m/min	70 m/min	70 m/min
Accumulator	yes	yes	yes
max. roll diameter up to *	1,200mm	1,000mm	1,200mm
	2,000mm		

(* Depending on shaft diameter, roll width and number of webs)

SMILE CONTROL SYSTEM

An innovative, intuitive and operator-friendly human-machine interface (HMI) with two 17-inch touch screens provides all the functions needed by operators and maintenance personnel to handle the complete line. Everything, from the input of the ratio of each raw material to the parameters of the winder can be dealt with from the main terminal, which is located in the casting section. A second touch screen at the winder that is linked to the main terminal allows winding parameter adjustment directly in the field of vision for the process.

Different access levels and features such as alarm management, recipe administration and remote service via ethernet/internet are standard. For extended trend analysis and quality documentation, data can be transferred to a data logging system via a separate PC, or existing data collection systems. The electrical equipment is either installed in an e-container or, depending upon the space requirement, in e-cabinets. Both customised solutions are supplied complete with electrical engineering, wiring and air-conditioning equipment. Only first choice and proven components are used for each device.

ADVANTAGES
<ul style="list-style-type: none"> Centrally operated touch-screen monitor, displaying all relevant data
<ul style="list-style-type: none"> Central control of all production parameters
<ul style="list-style-type: none"> Industrial Ethernet Powerlink connection to decentralised I/O points
<ul style="list-style-type: none"> Process data analyses
<ul style="list-style-type: none"> Integrated OEE (Overall Equipment Effectiveness)



control panel

HIGHEST QUALITY PRODUCTS



SML

EXTRUSION LINES – ENGINEERED TO PERFORM ►

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