

Film extrusion

1 – PP Tubular film process technology

Equipment for unoriented film

Figures 27 and 28 sketch the layout of equipment for unoriented flat and tubular film. The following is a brief description of the construction features of both plants.

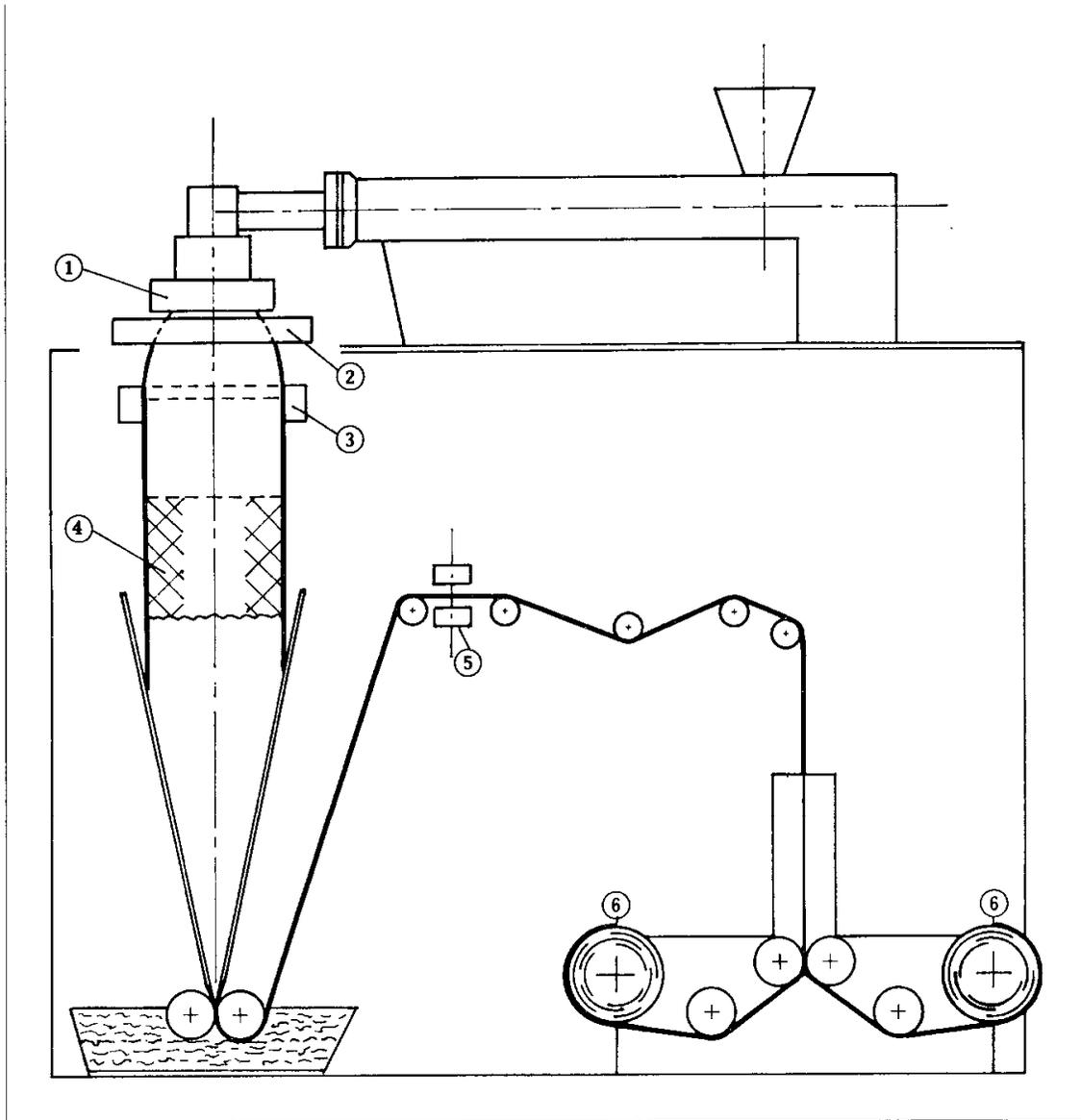


Fig. 27 - Plant layout for the production of blown film, water-cooled (1 = head; 2 = air-cooling ring; 3 = water-fed sizer; 4 = braid; 5 = corona treatment; 6 =takeup).

The equipment is provided with an extruder placed on a mounting at about 2-3 meters from the floor, which joins a rotating head facing downwards. The extruders normally have a diameter

varying from 45 to 90 mm, with throughputs from 35 to 140 kg/hour. Immediately under the head there is a blower ring and then the sizing and cooling group, fed with water, which comes into direct contact with the film so as to ensure an even and constant cooling at every point around the circumference of the tubular film. With a proper adjustment of the amount of the cooling water, its temperature and its even distribution, the resulting polypropylene film is highly transparent and glossy. The calibrator, which must be replaced whenever it is required to vary the size of the item, and the rotary head allow the obtainment of an item with precise and constant dimensions. The thicknesses attainable vary from 20 to 80 microns.

A pair of slide conveyors, adjustable, carry the tubular film to the pull rolls positioned at a few centimeters from the ground. The film is then taken up by a double group of friction winders passing in its travel, first through an air blowing device, at adjustable temperature, which completes drying of the material, and then through an electronic treatment which makes the material suitable for printing.

The minimum treatment intensity value, measured at the time of forwarding, should not be less than 35 dynes/cm², according to the watability method described in ASTM D 2578-67, or 75% if measured by the "scotch tape" method.

The latter test is carried out as follows:

- application of ink (Red Rotoflex Special 416 L, ICI Co. of Milan) over the treated face, by spread roller
- drying for 2 minutes at 70°C;
- application of the adhesive tape (Tesa 101 Transparent)
- evaluation of the inked area remaining after removal of the tape

The polypropylene film obtained with this technology is highly suitable for successive printing and welding operations which are briefly described hereafter.

Printing - Inks based on polyamide resins (the same as those used in the printing of polyethylene film) key well to the electronically treated film. The solvents are a blend of alcohols and aliphatic hydrocarbons, which are readily removed with not too high drying temperatures. Use can be made of either flexographic or gravure printing machines.

Welding -Unoriented film possesses all the weldability characteristics required in the packaging field. It can be welded in the same way as polyethylene film, that is by impulse, hot wire, etc., making appropriate allowances. The best bond strength values are obtained when the untreated faces are welded together; it is unadvisable to make the weld on the treated face.

2 - Flat PP Cast Film process technology

The equipment for the production of unoriented flat film is comprised of an extrusion group and a cooling station, the whole being mounted in-line and working on a horizontal plane.

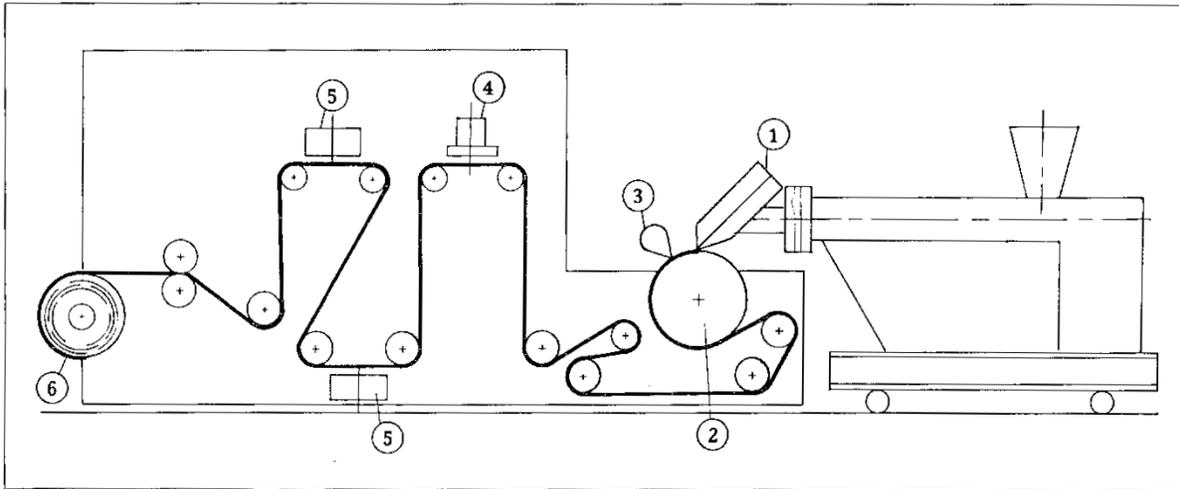


Fig. 23 - Plant layout for the production of cast film (1 = head; 2 = chill-roll; 3 = air blade; 4 = thickness measurer; 5 = corona treatment; 6 = takeup).

The first group is formed by a single-screw extruder, with dimensions that depend on its potentiality, and with a screw having a diameter varying from 60 to 150 mm; the head is flat, with a width from 800 to 2400 mm.

The cooling and take-off station is formed by a large-diameter (from 500 to 750 mm) water-cooled cylinder, on which the film leaving the extruder head is made to adhere by means of an air jet (air blade)

The cooled film is tensioned by a complex system of return rolls, trimmed at its edges and reeled. The scraps are ground and returned directly to the hopper. In passing from the chill-roll to windup, the film passes through a thickness control system and a system for the "corona effect" treatment, which makes it inkable.

Production capacity of the equipment varies with the dimensions of the extrusion group and goes from 60-70 kg/hour in the case of extruders with 60 mm diameter screws to 500-600 kg/hour using extruders with 150 mm diameter screws.

The linear speed of the film reaches about 200 meters/minute, while the range of available thickness goes from 20-25 microns to 180-200 microns.

By way of example, table 6 gives the physico-mechanical, optical, slip, permeability and chemical resistance properties of an unoriented film (thickness 25 microns) of polypropylene homopolymer. It will be seen that this film possesses the following:

Property	Unit	Values	Test method
Physico-mechanical			
Density	g/cm ³	0.89	ASTM D 1505
Tensile strength:	kg/cm ²		ASTM D 882
machine direction		250	
transversal direction		200	
Elongation at break:	%		ASTM D 882
machine direction		400	
transversal direction		350	
Yield strength	kg/cm ²	200	ASTM D 882
Tear strength:	g/25 μ		Eimendorf ASTM D 1922
machine direction		>15	
transversal direction		>150	
Impact strength (dart test)	g	140	internal MA 17106
Repeated bending resistance	number	>50000	ASTM D 643 B
Optical			
Haze	%	\leq 2.5	ASTM D 1003
Gloss at 45°	%	>80	ASTM D 2457
Slip			
Coefficient of friction after:	—		ASTM D 1894
1 hour		0.9	
24 hours		0.55	
7 days		0.4	
Permeability			
To water vapour at 38°C and 90% R.H.	g·25 μ /m ² ·24 h	8	ASTM E 96
To oxygen at 25°C	cm ³ ·25 μ /m ² ·24 h·atm	3700-5300	ASTM D 1454
To carbon dioxide at 25°C	cm ³ ·25 μ /m ² ·24 h·atm	9500-15000	—
Resistance to chemicals			
Strong acids	—	excellent	—
Strong bases	—	excellent	—
Oils and fats	—	good	—
Organic solvents	—	good	—

specific features, which allow its wide use in the packaging sector:

- Low specific gravity (0.89) and hence a higher yield (m²/kg), thickness being equal, as compared with other films. The high yields of polypropylene are evidenced by the following comparison between 25 micron thick films

1 Kg of	}	Polypropylene	covers	45 m ²
		conventional polyethylene	covers	43.5 m ²
		linear polyethylene	covers	42.5 m ²
		polystyrene	covers	38 m ²
		polyvinyl chloride	covers	32-38 m ²
		cellulosic film	covers	29-27 m ²

- high mechanical properties, which allow the use of lower thicknesses or provide a better performance with respect to other films
- high transparency and gloss
- Very high barrier towards water vapor and a practically nil humidity absorption
- heat resistance, which is related to the high melting point of polypropylene (170 °C); this allows polypropylene to be used in applications calling for sterilization
- good printability on flexographic and gravure printing machines
- high resistance to chemicals
- non-toxicity

Uses of Polypropylene unoriented film

Polypropylene film is widely used for the packaging of textiles, foodstuffs, sanitary items, pharmaceuticals, such as:

1. Cooked foods: bread cakes, confectionery in general
2. Knitwear
3. Hosiery, mainly women's. The stockings are bagged either by hand or semiautomatically; automatic packaging is also widely adopted, starting directly from single-folded reels
4. Shirts
5. Blankets and table-cloths
6. Breadsticks, biscuits and bakery products in general
7. Flowers
8. Separator packs for pharmaceutical tablets and capsules. The lid of the separator pack is usually in a polypropylene/aluminum laminate.
9. Laminates. The basic purpose of the use of laminates is the obtainment of a combination that unites the properties of the individual components. Lamination of the polypropylene film with other films, whether or not transparent, allows a wide number of requirements to be met in the field of packaging. Some of the important laminates with the use of polypropylene film are:
 - a. paper/ polypropylene, for the production of disposable plates
 - b. aluminium/ polypropylene, for the production of bags for cooked chicken
 - c. polyester film/aluminium/ polypropylene, for sterilizable bags for precooked foods (hams, pork sausage products).