BOPP PP Bioriented film

Equipment for bioriented film

Figures 29 and 30 sketch the layout of plants for tubular and flat bioriented film. The following are the summarized construction features of both plants.

1 - TUBULAR FILM Process Technology

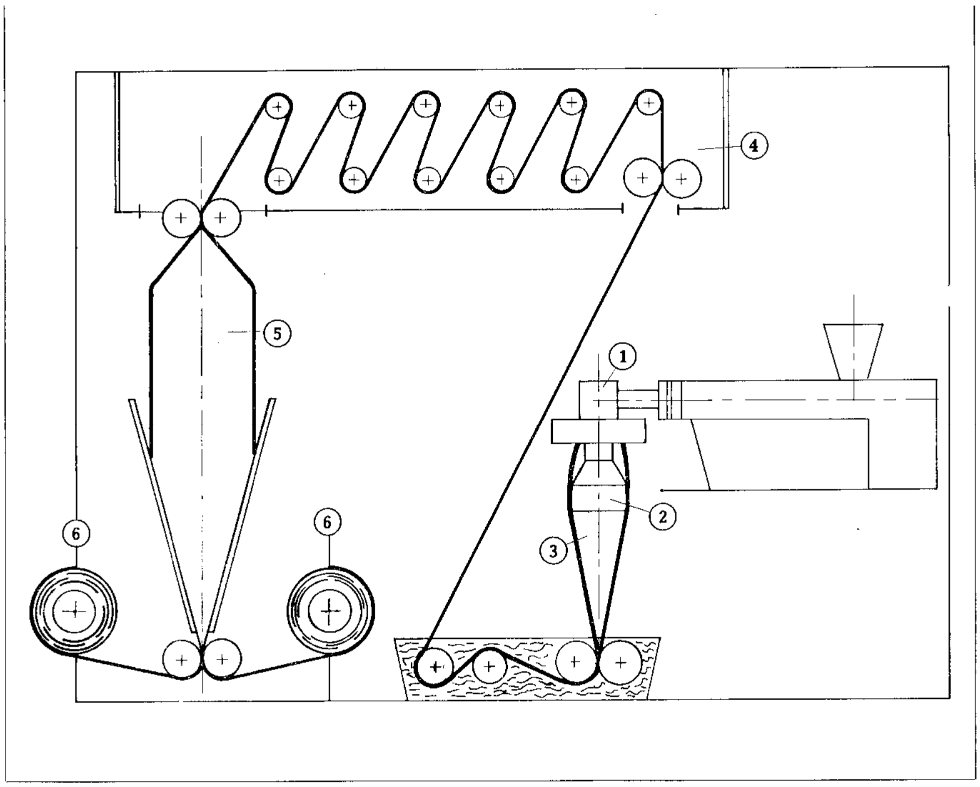

Fig. 29 - Plant layout for the production of bioriented blown film (1 = head; 2 = sizer in water; 3 = water cooling; 4 = steam-heated oven; 5 = blown and bioriented film; 6 = takeup).

The equipment most commonly used in the world is built by the Italian Company Prandi; it is comprised of a 120 mm diameter extruder (L/D ratio = 33), which joins a tubular head facing downwards, immediately followed by the sizer group. The film leaves the film-forming head with a thickness of about 0.9 mm and is immediately cooled with refrigerated water running along the outside and inside wall of the film. The water cooling the outer wall is collected in a tank at the base of the plant; the water cooling the inner wall is removed under vacuum through a series of holes bored in the sizer.

The cooled film is carried to an oven heated at about 160°C by steam; at the outlet, the film is swollen by a compressed air gun up to a blow ratio of 5.5:1. At the same time it is stretched longitudinally with the same ratio. The film is then subjected to flame treatment, which is necessary for adhesion of the hot-melts and ink, and then to stabilization in an oven with a biaxial shrinkage of about 7%.

2 - FLAT FILM BOPP Process Technology

The technology for the obtainment of flat BOPP film provides for flat extrusion and subsequent bi-stretching in the longitudinal and transversal directions.

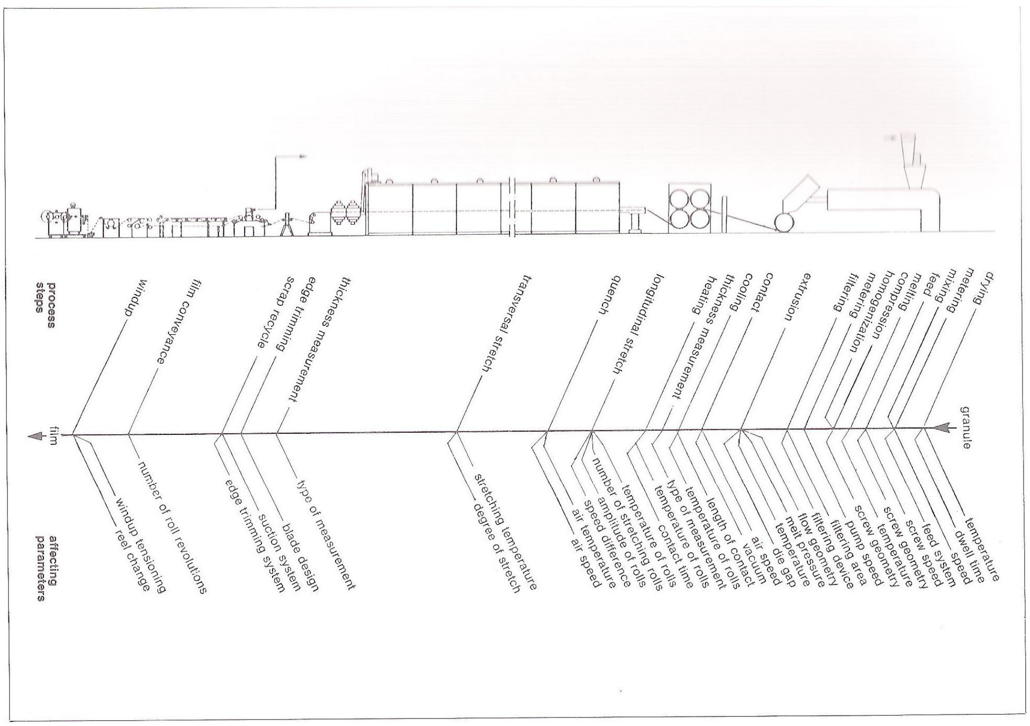

Fig. 30 - Production layout for bistretched film.

The BOPP plants consist of:

Extruder - Use is normally made of single-screw extruders with diameters varying from 60 to 300 mm and with a length that is always above 30 diameters.

Table 7 - Throughput range for the extrusion of polypropylene versus screw diameter

Extruder diameter, mm	Throughput range, kg/hour
90	220-250
120	300-350
150	450-500
200	700-850
225	1000-1200
250	1300-1500
300	1700-2000

The metering precision to ensure dimensional stability of the film is often provided by a metering pump placed immediately downstream of the extruder. For high throughputs, or for very high film qualities, this pump is substituted by a hot-melt extruder. In the latter way the homogenization and metering steps are carried out by separate units.

Of special importance is the filtration step of the melt, which takes place through filtering devices, from 10 to 20 microns, under a pressure gradient from 20 to 100 bar. For this purpose, filters have been developed with a wide filtering area (up to 46.5 m^2) having a double chamber which, by arranging the filtering unit in the form of a disc, afford a maximum surface area with a minimum chamber volume. The double-chamber design allows the filter to be changed without interruption of the flow.

Die - Use is made of a die with adjustable lips, whose cross-section is shown in fig. 31. The through a coat-hanger-shaped channel and a bowl, which ensures the best rheological The thicknesses obtainable range from 15 to 500 microns

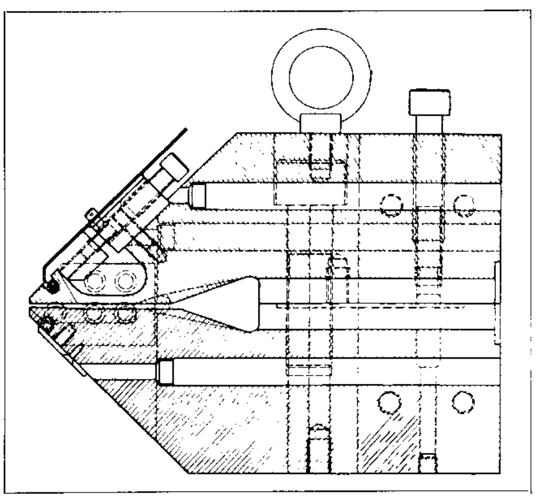

Fig. 31 - Cross-section of a die.

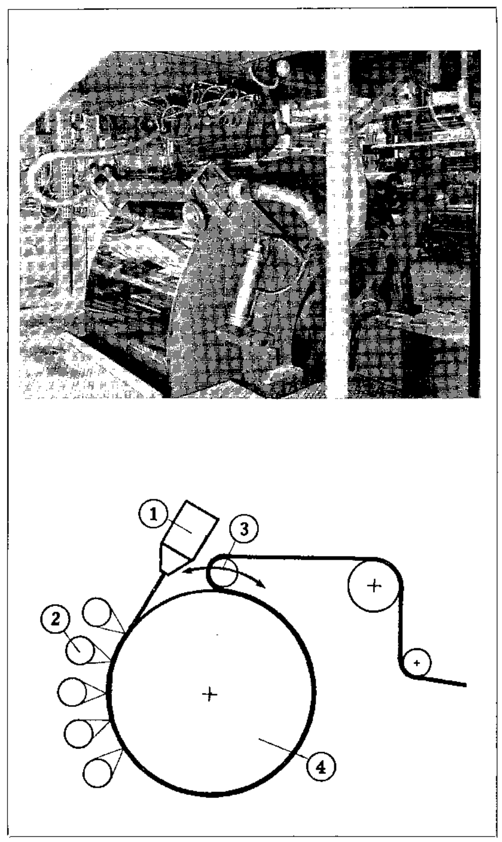

Fig. 32 - Casting unit (1 = die; 2 = air blade; 3 = casting roll; 4 = film detachment roll).

Casting unit - With crystalline thermoplastics the film must be cooled below the melting point of the crystallites before it is subjected to the stretch process. This thermal drop must be rapid and uniform so as to obtain a homogeneous crystalline structure. To that end, the chill-roll system is the most appropriate. Use is normally made of chill-rolls having a diameter from 600 to 2500 mm, according to film thickness and extrusion speed (fig. 32).

To ensure a good film contact with the chill-roll, the film is made to adhere to the latter by means of an air blade.

The casting roll has a chromium-plated and tempered surface held at the preset temperature with minimum adjustments (maximum fluctuation for temperatures from 15 to 150℃: ± 1℃).

Stretching unit –

To increase the mechanical, optical and impermeability properties of the film, it must be stretched in both directions by application of a tensioning force.

The longitudinal stretch is made by means of pairs of rolls rotating at different speeds (stretch ratio oscillating between 3.5:1 and 5:1).

Unoriented film is fed to a conditioning oven in which it is transversely stretched by pairs of grip tracks that rotate on diverging rails (the stretch ratio normally used is between 7:1 and 10:1).

Orientation is followed by an in-line annealing operation to obtain a certain detensioning, and then the film is taken up and rewound.

There are also plants in which both stretches, longitudinal and transversal, are made together (fig. 33).

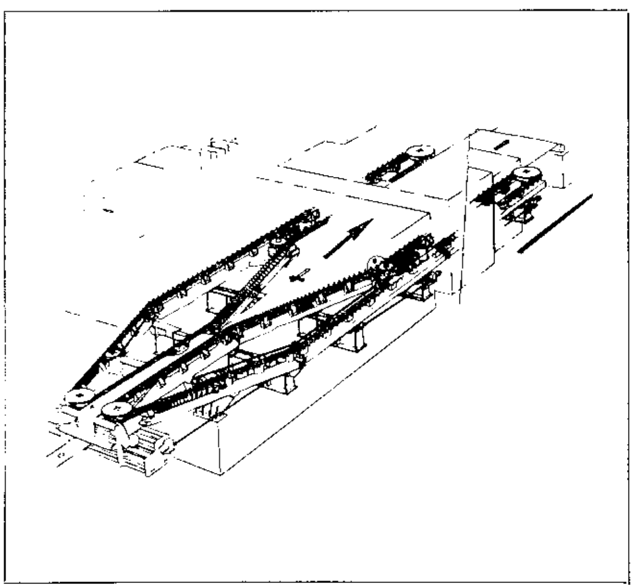

Fig. 33 - Stretching unit for simultaneous biaxial stretch.

Fig. 34 compares the two BOPP stretching systems.

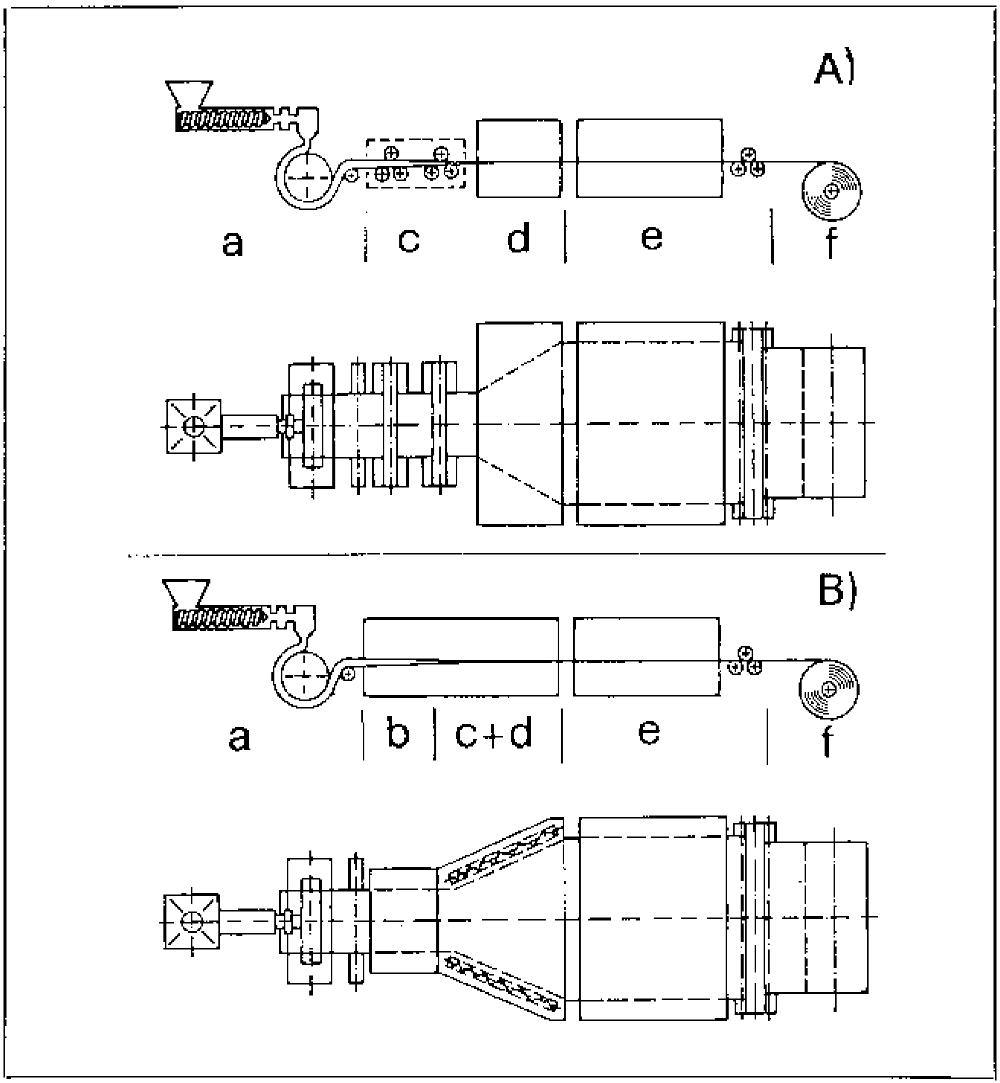

Fig. 34 - Comparison between the stretching process in two steps (A) and simultaneous (B). (a = production of primary film with extrusion, filtration, casting and cooling; b = heating of film to stretching temperature; c = stretch in the longitudinal direction; d = stretch in the transversal direction; e = dimensional stabilization; f = windup cutting).

Fig. 35 gives temperatures for the various steps of the production process of BOPP film.

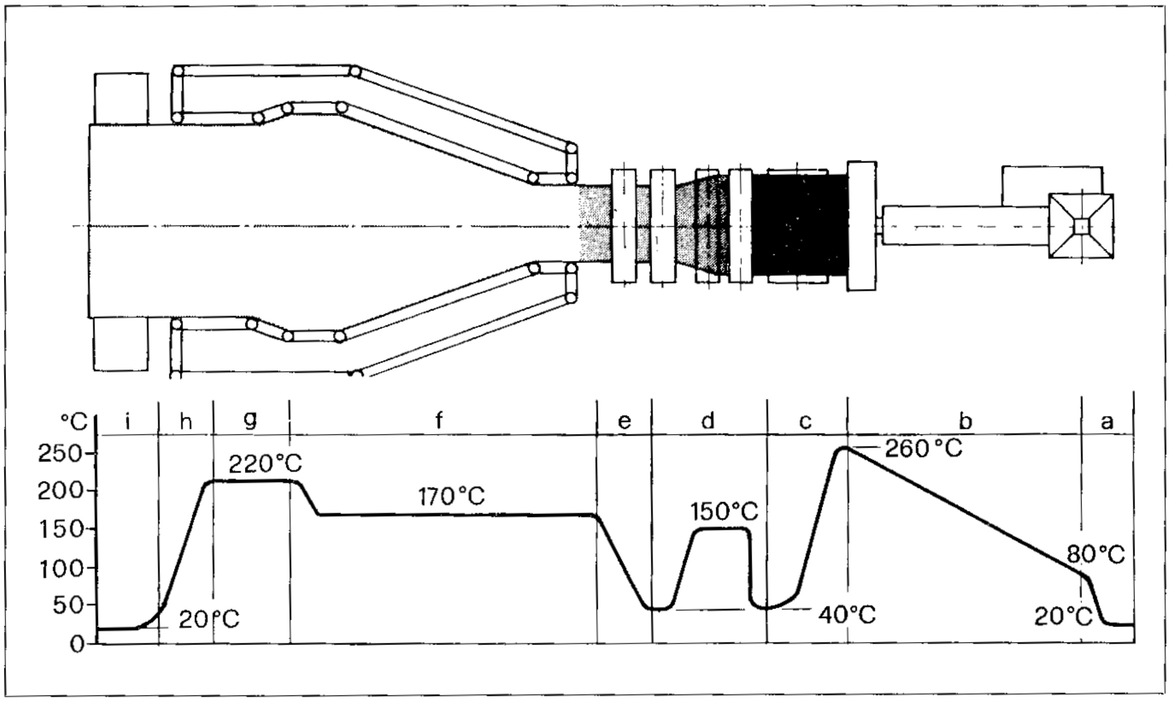

Fig 35 - Process temperature (a = preheating; b = extrusion; c = cooling; d = longitudinal stretch; e = heating; f = transversal stretch; g = thermosetting; h = cooling; i = windup).

Properties of BOPP films

Table 8 compares an example of the physico-mechanicai, optical, permeability and chemical resistance property values of a bioriented flat film with those of a tubular film, both in polypropylene and with a thickness of 25 microns.

Comparing these with the values reported in table 6 relevant to unoriented polypropylene film, it can be seen that the biorientation process increases the mechanical properties (with the exception of tear strength), impermeability properties and, in the case of flat bioriented film, the optical properties too.

Against this, BOPP film is difficult to weld. unless it is coextruded/laminated (with materials having a low weldability temperature), or else lacquered.

Property	Unit	Values		Test method
		bioriented flat film	tubular film	
Physico-mechanical				
Density	g/cm^3	0.9	0.9	ASTM D 1505
Tensile strength:	kg/cm^2			ASTM D 882
machine direction		1500	1500	
transversal direction		2500	1500	
Elongation at break:	%			ASTM D 882
machine direction		100	90	
transversal direction		40	60	
Tear strength	g/25 μ	8-12	—	Elmendorf ASTM D 1922
Impact strength (dart test)	g	400	390	internal MA 17106
Repeated bending resistance	number	>70000	—	ASTM D 643 B
Optical				
Haze	%	<1.5	<3.5	ASTM D 1003
Gloss at 45°	‰	⩾85	⩾75	ASTM D 2457
Permeability				
To water vapour at 38°C and 90% R.H.	$g \cdot 25\mu/m^2 \cdot 24\ h$	3-5	3-5	ASTM E 96
To oxygen	$cm^3 \cdot 25\mu/m^2 \cdot 24\ h \cdot atm$	1600-2300	1800-2500	ASTM D 1454
To carbon dioxide at 25°C	$cm^3 \cdot 25\mu/m^2 \cdot 24\ h \cdot atm$	4200-6500	4500-7000	—
Resistance to chemicals				
Strong acids	—	excellent	excellent	—
Strong bases	—	excellent	excellent	—
Oils and fats	—	good	good	—
Organic solvents	—	good	good	—

Uses of polypropylene BOPP film

The most varied types of BOPP film are to be found on the market; these films have been given special properties according to the end-use to which they are to be put. More precisely:

- Electronically or flame-treated film for a good keying of inks or adhesives
- Antistatic film for fast packaging
- Film laminated or coextruded with materials having a low weldability temperature, so as to make it processable on the same machines used for cellulosic film
- Lacquered film to impart, in addition to good weldability, high barrier properties.

According to the different types of film, the more common applications are:

For treated film

- Coating of paper or cardboard (book covers, picture postcards, posters, etc.), using adhesives The film gives the laminate a high gloss and protects the paper or cardboard against abrasion.
- Technical uses (support for adhesive tapes and tape winding of telephone cables). The advantage here is given by the film's excellent mechanical and electrical properties.
- Laminated with other flexible film and/or aluminum and/or cellophane, (pouches for snacks, for coffee, etc.).

For lacquered or coextruded film

- Automatic packaging of fresh bakery products (cakes, small "panettoni", bread, buns, etc.) and dry bakery products (biscuits, breadsticks, crackers). The advantage in this case is given by the lacquered film's high protection from moisture: moisture, in fact, must not enter the bags containing dry products and it must not escape from the materials with a high moisture content
- Automatic packaging of potato crisps, snacks and confectionery. The advantage in this case is the high resistance to oils and fats and a high barrier against oxidation.
- Packaging of spaghetti and allied products. The advantages are: high protection against the effect of environmental conditions (loss of weight of spaghetti products in a dry environment or, vice versa,
  absorption of moisture in humid environments) and maximum resistance to mechanical stresses (impact against walls, puncturing by the contents), even at very low temperatures.
- Overwrapping of boxes and parallelepiped-shaped packages (packets of biscuits, chamomile, tea, etc.). Considerable advantages are obtained from the use of the film: high optical properties, but above all its resistance to deformation from moisture, its crease-proof, impact strength and cold resistance properties, which drastically reduce the number of broken or discarded packagings.