meetingPACK 2017

3rd EDITION

Coextrusión de bi-ax films barrera a través de tecnología

Coextrusion of bi-ax barrier films by "two and three-bubble" technology

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ainia AIMPLAS

CO-EXTRUSION OF BARRIER BI-AX FILMS BY TWO AND THREE-BUBBLE TECHNOLOGY

meetingPACK 2017 3rd EDITION

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MACRO® ADVANCED EXTRUSION SYSTEMS

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Macro Engineering & Technology Inc.

Extrusion Systems:
- Blown Film
- Cast Film
- Bi-oriented Film
- Sheet
- Foam

Macro Technology Inc.

Components:
- Coextrusion Dies
- Air Rings
- Winders

Consulting

Training

Line Audit

INTRODUCTION

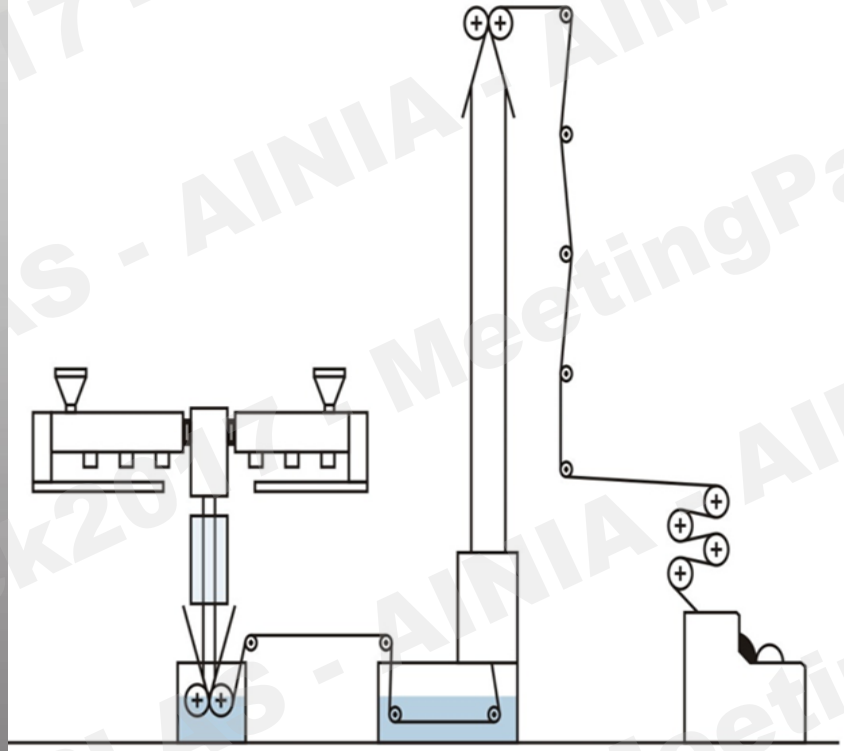
- Double bubble technology is used to make multilayer barrier shrink films. A number of different resins are being used to make such a film:
  - Nylon 6 and Nylon 6/66
  - EVOH (different ethylene mole%, e.g.,EVOH-38)
  - PVdC
  - Polyolefins: LLDPE, PP, PP-copolymer
  - Specialty resins: EVA, EMA
  - Tie resins: Maleic Anhydride modified LLDPE, LDPE or EVA

NOMENCLATURE FOR SHRINK FILM

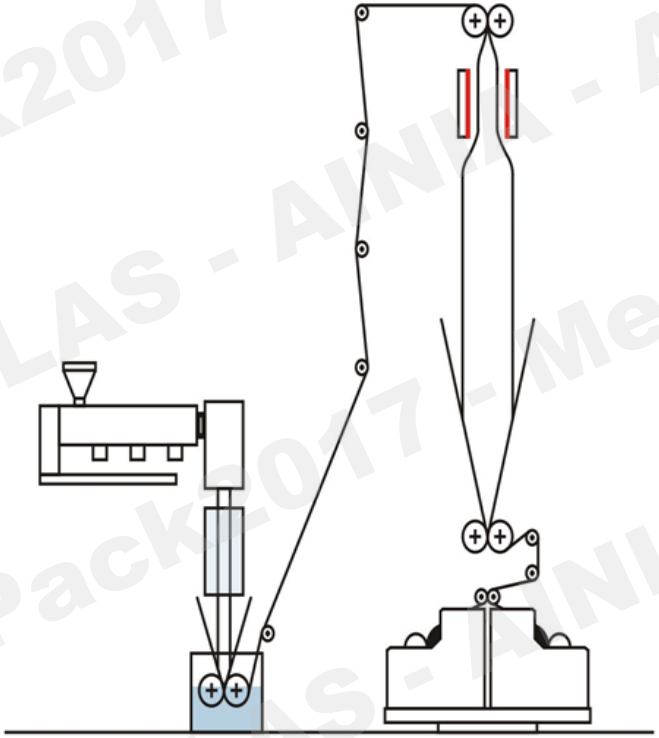
- Multilayer barrier shrink films produced via double bubble technology is often divided (based on % shrink) into the following categories:
  - High shrink film (40% to 70%)
    - Barrier shrink bags for fresh red meat and cheese
  - Medium shrink film (20% to 30%)
    - Barrier shrink bags for processed meat and cheese
  - Low shrink film (5% to 15 %)
    - Casing film for sausages

DOUBLE BUBBLE LINE LAYOUT:
Two different types based on primary tube re-heating system

Water re-heating



Infra-red re-heating



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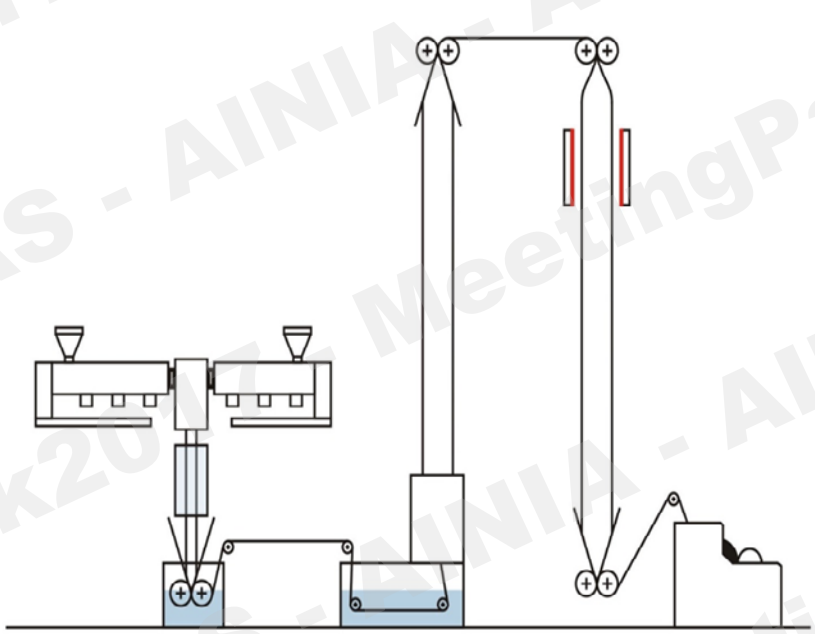
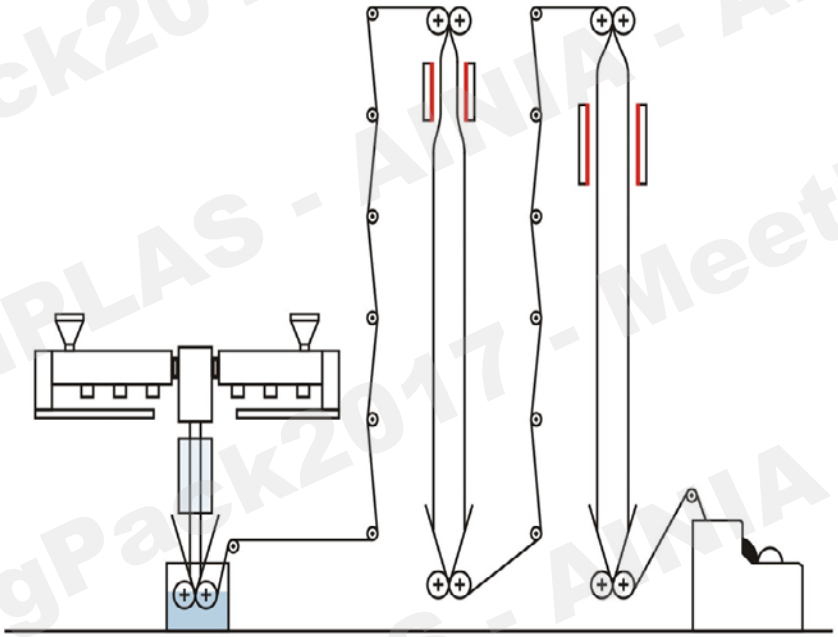
DOUBLE BUBBLE WITH ANNEALING LINE LAYOUT:
Two types

Second Bubble: two types of re-heating systems
Third bubble: annealing by Infra-red for both layouts





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EQUIPMENT FOR TWO/THREE BUBBLE TECHNOLOGY (UPTO 13-LAYER LINES)

- Material handling & gravimetric system
- Smooth bore and grooved barrel extruders
- Screen changer, melt pump (optional) and adaptors (feed pipes)
- Single or multilayer stackable dies
- Primary tube (first bubble)
- Cooling & calibration system (collapsing frame, nip and water circulating system)
  - Cascade water cooling rings
  - Water cooling ring with vacuum calibrator

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EQUIPMENT FOR TWO/THREE BUBBLE TECHNOLOGY (UPTO 13-LAYER LINES) (Continued)

- Heating system
  - Hot water bath
  - Infra-red heaters (on annular tube)
- Second bubble for bi-ax (MD & TD) orientation
- Collapsing frame & nip (stationary or oscillating)
- Gauging system for wide films (GBS, IR or X-RAY sensors)
- Annealing or heat stabilization of film
  - Annealing rolls for flattened film
  - Third bubble for annealing using infra-red heaters or steam
- Surface treatment
- Winder (roll handling system)

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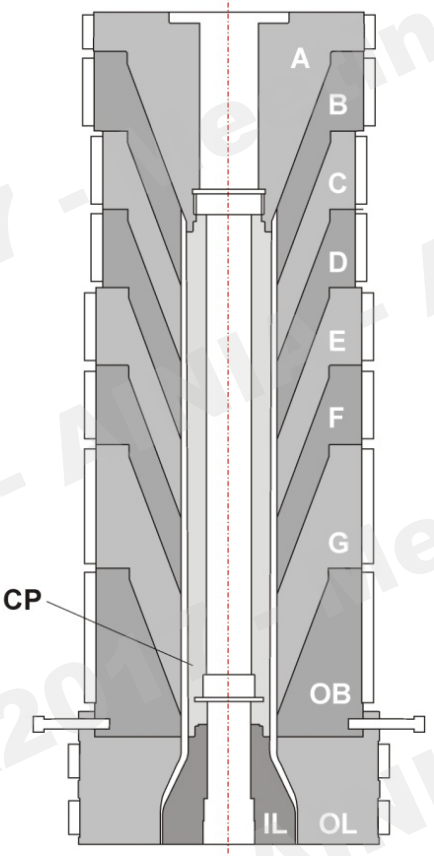
CO-EXTRUSION DIE

7-LAYER TAPER-PACK CO-EXTRUSION
DIE FOR HEAT SHRINKABLE BI-AX FILM



7-LAYER TAPERPACK COEX DIE
IL & OL: INNER & OUTER LIPS
CP: CENTER PIN
OB: OUTER BODY
A. B. C..... F. G: SPIRALS FOR 7 LAYERS

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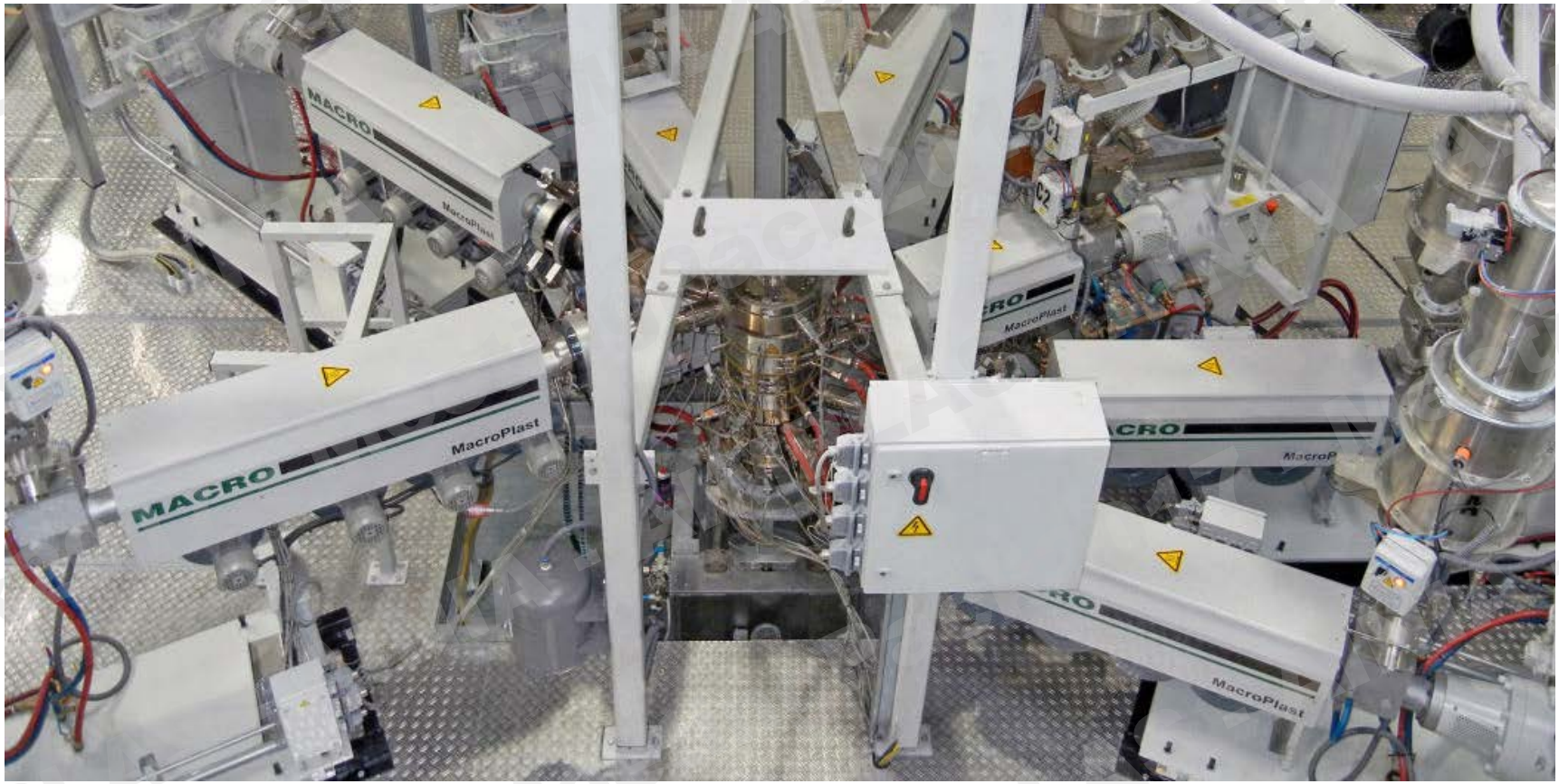
LAYOUT OF EXTRUDERS / CO-EX DIE



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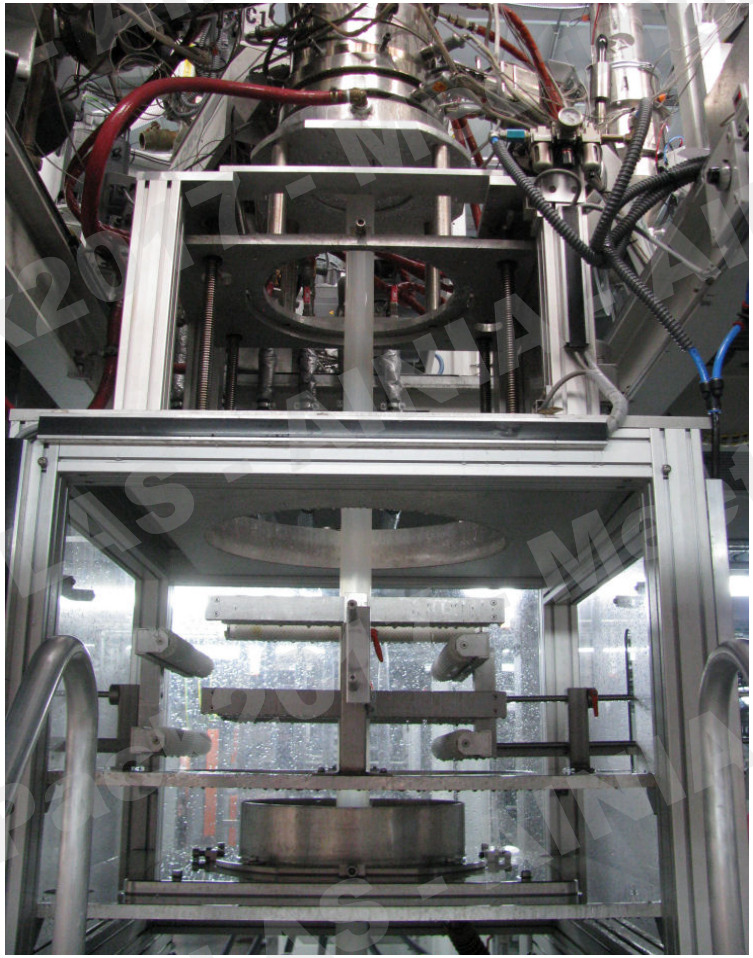
EXTRUSION OF THE PRIMARY TUBE *(FIRST BUBBLE)*

- Primary tube is relatively thick (~0.3mm to 1mm). Aim is to rapidly cool this primary tube to maximize amorphous phase and minimize formation of crystalline phase in the polymers (primary tube).
- Therefore cold water quench devices (immersion bath, cascade rings or water ring) should provide very fast and efficient cooling to the extruded primary tube.
- Water temperature variation around the circumference of the primary tube should not exceed ±1ºC.



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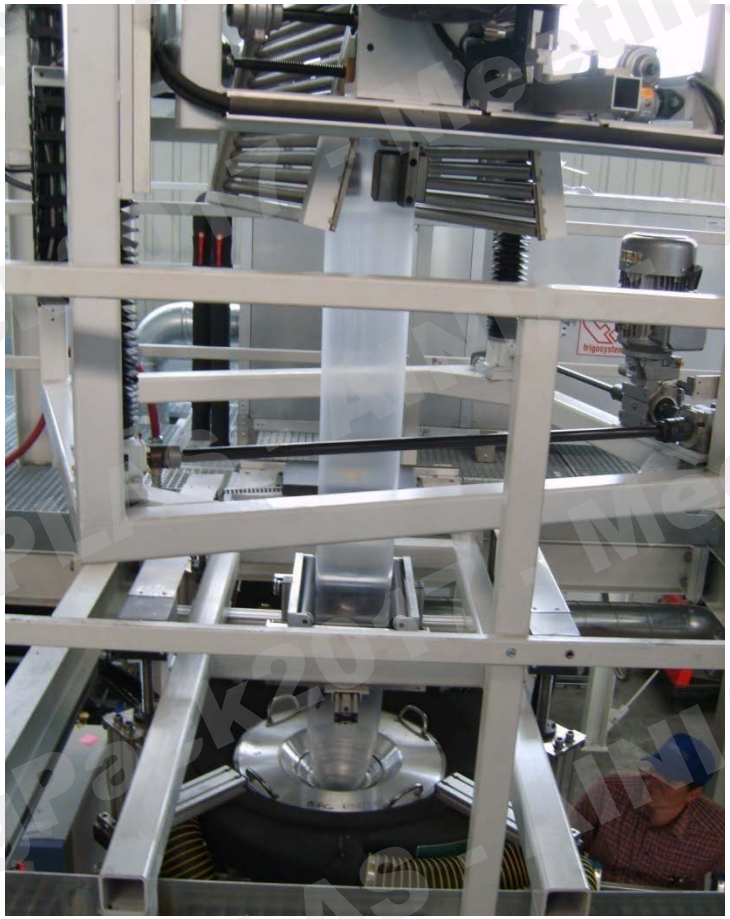
BI-AXIAL ORIENTATION (SECOND BUBBLE)

- The heated primary tube is inflated and simultaneously stretched in the second bubble to obtain biaxial orientation (MD & TD):
  - ➢ MD orientation is controlled by the speed ratio between the primary nip and secondary nip (after orientation).
  - ➢ TD orientation is controlled by the inflation or blow-up-ratio (BUR).
- The second bubble (oriented film) is cooled by an air ring and randomized & collapsed as flexible folded film.



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BI-AXIAL ORIENTATION (SECOND BUBBLE)

- The second bubble (oriented film) is randomized by oscillating nip with turning bars & collapsed as flexible folded film.

ANNEALING & WINDING EQUIPMENT FOR TWO BUBBLE TECHNOLOGY

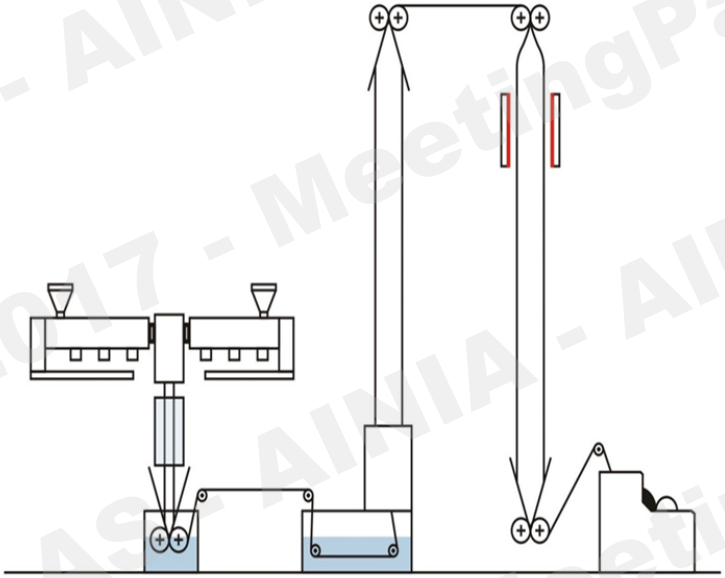
- Annealing
  - In double bubble technology the collapsed film (from second bubble) is passed over heated rollers for annealing (or stress relaxation) and eventually passed over cold rollers before winding.

- Winding
  - This annealed film is wound as tubing or sheeting using a surface winder with gap mode or turret winder.

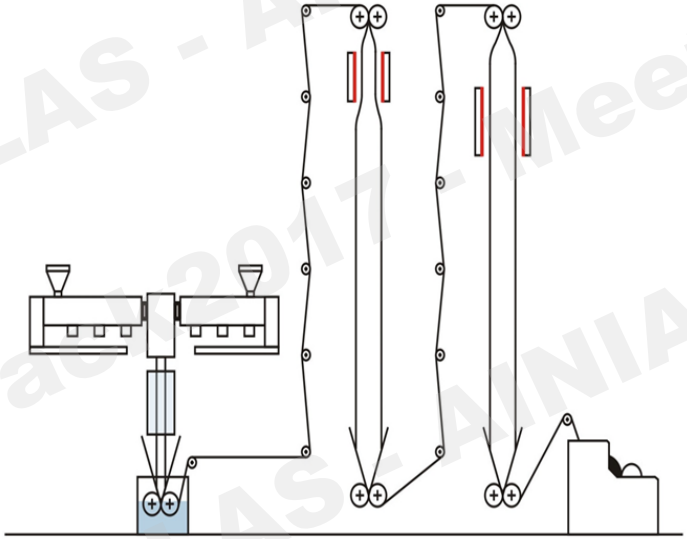
ANNEALING & WINDING EQUIPMENT FOR THREE BUBBLE TECHNOLOGY

- In three bubble technology, the collapsed folded film (from second bubble) is re-inflated into a third bubble to be annealed by infra-red heaters; film is subsequently collapsed, cooled and wound as tubing or sheeting.

Water re-heating



Infra-red re-heating



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BI-AX SHRINK FILMS WITH PA
Why annealing is done using a THIRD BUBBLE?

- For PA (resin specific) based bi-ax films, the collapsed second bubble is re-inflated into a third bubble and film is heat set by exposing the film to a higher temperature (as compared to ambient temperature), this can be achieved by infrared heaters, hot air or steam.

FILM STRUCTURES

Bi-ax (low and high) shrink films with PA, PP, EVOH and PVdC as barrier materials with appropriate tie, skin and sealant layers are used for fresh red meat, processed meat and cheese packaging applications.

These are some of the typical structures of the bi-ax film:

- 3 Layers
  - PA/TIE/PE
  - PA/TIE/PA
  - EVA/PVdC/EVA
- 5 Layers
  - PA/TIE/PE/TIE/PA
  - PA/EVOH/PA/TIE/PE
- 7 Layers
  - PA/TIE/PA/EVOH/PA/TIE/PE
  - PE/PE/EVA/PVdC/EVA/PE/PE
  - PE/EVA/PVdC/EVA/PVdC/EVA/PE
- 9 Layers
  - PA/TIE/PE/TIE/PA/EVOH/PA/TIE/PA

Important! A number of bi-ax film structures are protected by US, Canadian and European patents.

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MATERIALS AND STRUCTURES: POLYAMIDE

- In the bi-ax film applications, PA6 is typically blended with copolymer nylon such as PA6/66 or PA 6/12 to get optimum cost vs. performance of the film.

- Depending upon the nylon (or its blends), BUR, DDR and annealing conditions, PA6-based films have shrinkage from 15 to 30%.

- Nylon films have superior heat resistance, excellent puncture resistance, toughness and scuff resistance and have good O_2 and aroma barrier.

MATERIALS AND STRUCTURES: EVOH

- EVOH is a copolymer of ethylene and vinyl alcohol. EVOH material is characterized by ethylene mole% in the copolymer, EVOH-38 means 38 mole% of ethylene.

- As the ethylene content in the copolymer increases, material becomes more flexible and easier to process, but the barrier properties (for oxygen) declines.

OXYGEN & WATER VAPOR BARRIER PERFORMANCE

MATERIAL	OTR	WVTR
LDPE	420-450	1.0-1.5
PP	190-280	0.5–0.9
Nylon 6	2.2-5.0	18.0-23.0
Nylon 6/66	2.2-5.0	18.0-23.0
EVOH-32	0.02-0.05	1.4-1.8
EVOH-38	0.09-0.18	2.1-2.5
PVdC (vdc/vc)	1.5-2.5	0.4-0.9
PVdC (vdc/ma)	0.05-0.07	0.03-0.05

OTR: cc·mil/100 in^2 ·day·atm @73•F and 0% RH
WVTR: g·mil/100 in^2 ·day @ 100•F and 90% RH

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Case study 1: Barrier (7-layer) high shrink bi-ax film

Film structure of 7-layer bi-ax (high shrink film):
PE/EVA/PVdC/EVA/PVdC/EVA/PE

- Die: 90mm (3.5”)
- Tubing width: 460 mm
- Film thickness: 60 microns
- Output: 120 kg/h
- Shrinkage: 60% MD/TD
- Printable
- Based on Macro’s patented structure

Case study 2: Barrier (7-layer) high shrink bi-ax film

Film structure of 7-layer bi-ax film (high shrink): mPE/PE/tie/EVOH/tie/PE/mPE

- Die: 90mm (3.5”)
- Tubing width: 390 mm
- Film thickness: 65 microns
- Output: 110 kg/h
- Shrinkage: 40% MD/TD
- Printable

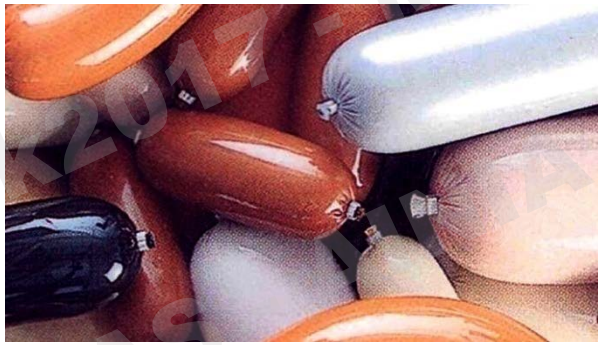
Case study 3: Barrier (5-layer) low shrink bi-ax film

Film structure of 5-layer bi-ax (low shrink film): PA/tie/PA/tie/PA

- Die: 60mm (2.3”)
- Tubing width: 140 mm
- Film thickness: 50 microns
- Output: 128 kg/h
- Shrinkage: 15% MD/TD
- Printable and superior mechanical properties

BARRIER FILM APPLICATIONS

- Single or multilayer casing for meat films consists of PA or PVdC with appropriate tie and skin layers.
- Single or multilayer bi-ax shrink film for meat and cheese consists of barrier layers such as PVdC, EVOH, PA and PP with appropriate tie and skin layers



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CONCLUSIONS

- Double bubble technology can be used to fabricate films for a number of different applications such as high shrink film for fresh red meat and cheese applications and low shrink films for lamination and lidding film.

- Selection of the resins for shrink film is based on the barrier, optical, and mechanical properties requirement (to name a few), such as EVOH, PVdC and Nylon barrier resins, skin layer of PA, PP or PE, sealant layer of specialty polyolefins, these different layers are bonded with appropriate tie resins to make a co-ex shrink film.

- Selection of a technology is based on the end application requirement.

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¡Gracias!
Thank You!

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