Flexible Plastic Packaging
Part Three
Blown Film Extrusion- Best Practices

By
Dr. Yatish B Vasudeo

Innovation Consultation

METHODOLOGY FOR FINALIZING THE BEST PRACTICES

BENCHMARKING

- **Units of Analysis:**

Blown film extrusion process viz pallet feeding unit, extruder unit, die unit, bubble cooling and stabilizing unit, bubble take-off unit and film winding unit.

- **Variables of Analysis:**

Material consumption and waste creation, energy consumption, process based product quality, labor productivity and unwanted outputs (environmental).

BENCHMARKING

- Each dependent variable is analyzed focusing independent process variables for its cause and effect using ‘fishbone diagram’.
- The commonality in process variables are identified and benchmarked for blown film extrusion process.
- Lastly, best practices are reviewed for each process variables to reduce precision gaps in independent variables across the industry.
- **Boundaries of Work:** The work excludes technology advancements, etc.

IDENTIFICATION OF BEST PRACTICES

Fishbone Diagram of Blown Film Extrusion Process and its Analysis:

- The main dependent parameters for process analysis are material and resource consumption, energy consumption, throughput, product quality and unwanted environmental effects.
- The horizontal main bone of fishbone diagram depicts blown film extrusion sub-processes. The main branches are sub-process variables. The fishbone diagram is shown in next slide.

Fish Bone Diagram

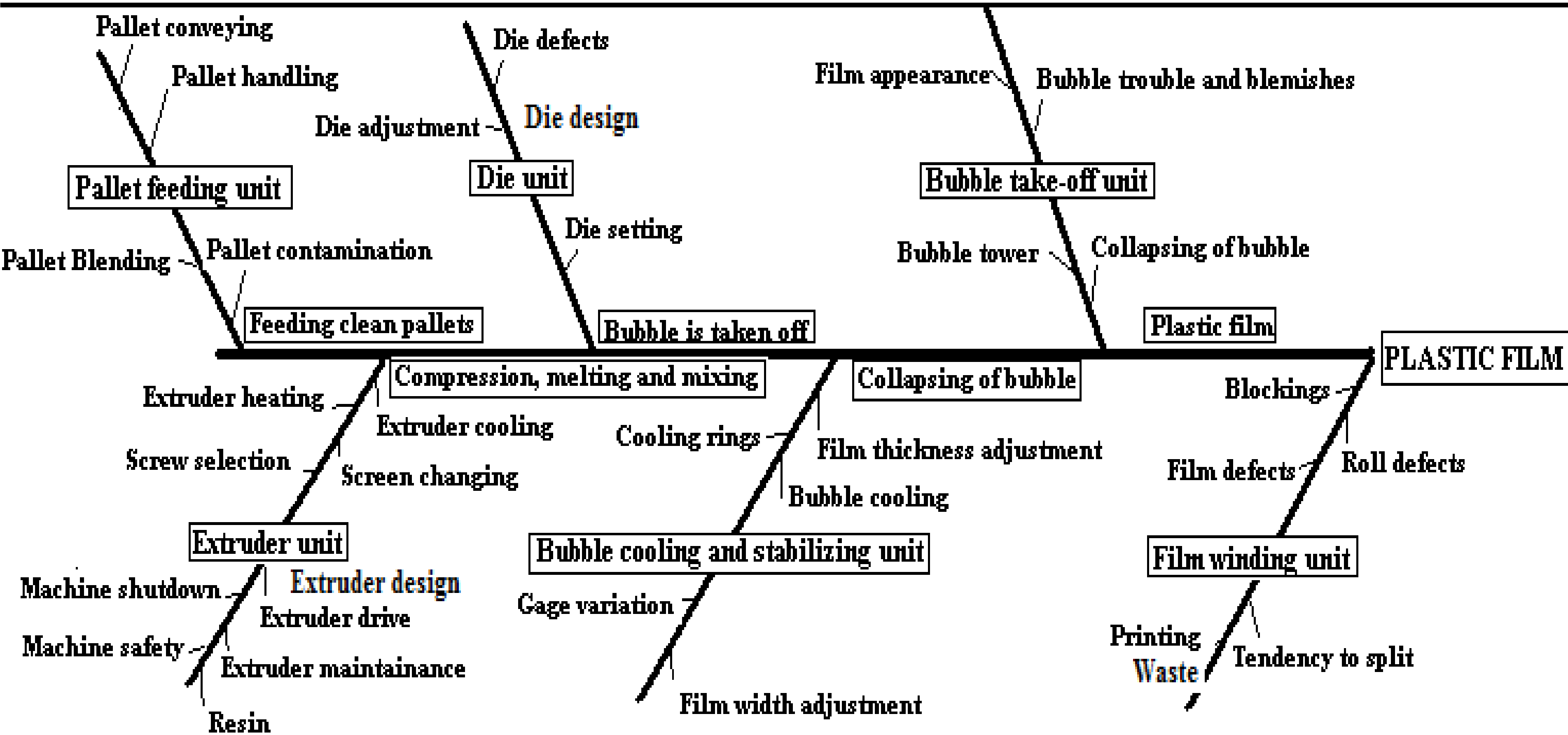

Figure04. Fishbone diagram for blown film extrusion process (Variables: Energy / Material consumption, Throughput, Product quality)

Fish Bone Diagram- Diagram

- It is seen from the critical analysis of ‘fishbone diagram’ that technology apart, process variables are purely depending on practices followed at sub-process level. It is obvious that practices are experienced based and tailor made by operator.

- The variation in process variables have direct relationship with practices followed at task level. It is also conformed from the variation process outcome i.e. material consumption, energy consumption, throughput and product quality.

- This variation is required to be minimized to encourage visible identification of technology related improvements to be adopted. It requires adoption of best practices.

Benchmarking Process Outcomes of Blown Film Extrusion Process

Material

- Material consumption is best measured with material productivity as a ratio of material used in final product to total material input.
- Blown film extrusion process material losses in material handling, conveying, feeding, extruding, down gauging, setup, purging, etc.
- From 1.5 to 3 % of such losses, it could be reduced to 0.5 % as benchmark by following best practices.

Benchmarking Process Outcomes of Blown Film Extrusion Process

Energy consumption

variation is 5.87 to 31.42 MJ for processing one kilogram of plastic films. (Findings of Industry Study)

Draw Targets e.g.

Benchmarking Variables	**Existing Range**	**Benchmark**
Material process waste	1.5% to 3%	0.5%
Energy Consumption	11.4 MJ to 31.42 MJ	5.87 MJ
Capacity Utilisation	50 to 60%	100%
Annual Average Production	500 tons	1000 tons

SUMMARY OF ACTIVITIES TO ACHIEVE BEST PRACTICES IN BLOWN FILM EXTRUSION

The blown film extrusion process is divided in to six units

- pallet feeding unit,
- extruder unit,
- die unit,
- bubble cooling and stabilizing unit,
- bubble take-off unit and
- film winding unit

for description of activities to achieve best practices.

Pallet Feeding Unit

Sub Unit & Issues

- Material condition / handing:
- resin contamination

Activities to achieve best practices

1. Use of extensive system of filters, cyclones, elutriators, etc.

2. Roughen (600 to 700 RMS roughness by sand blasting or # 55 shot with 55 – 60

3 RH produced at 900 RMS roughness) the interior wall of piping system.

4. Eliminate long radius bends wherever possible.

5. Rotate transfer piping at 90O at periodic interval.

6. Periodic washing of material transfer / handling equipment.

7. Ensure that suction line is not lying on the ground when system is started.

8. Place air filters over hopper and bottom valves during unloading the pallets.

9. Purge the lines with air first and then with a small amount of product prior to filling storage silos or bins.

Blending **1.** Blending programs with designated practices to be adopted

Extruder Unit

Hopper

1. Hopper throat can be water cooled to prevent bridging over.
2. Optimize and control the water amount and temperature to obtain maximum efficiency.

Barrel

1. Water cooled the barrel and has as many as 12 helical grooves.
2. Extruder start up heating is done by electrical heaters.
3. Use temperature controlling mechanism to regulate heater bands and cooling devices or envisage the manual procedure. Barrel temperature is generally in the range of 140 oC to 190 oC just in front of the hopper and about 220 oC near the screen pack.

Extruder Unit

- **Screw**

1. Screw should be at least 24 times and preferably 28 to 30 times as long as its diameter and properly designed

2. Monitor the temperature of screw between 25 oC to 80 oC by temperature controller or manual methods.

3. In case of sudden machine shutdown and minor bridging the adhering pellets can be cleared by inserting a flinch rod made from the resin into the feed throat while the screw is turning over slowly. If there is major bridging, then clean the extruder by opening it.

4. More efficient melt separation screws with a barrier flight and mixing head can be retrofitted for the extrusion of LDPE, HMW-LDPE, LLDPE, HDPE, HMW, HDPE and blends, plus additives and reground material.

Extruder Unit

Screws

5. The speed of these drives should be regulated at 2% or less of base motor speed with a 95% load change. Solid state DC power cabinets should be located where temperatures do not exceed 100°F or they should be fitted with a filter and cooling blower.

6. Surging can result, particularly when two or three zones are cooled simultaneously. Proportional control is needed to eliminate shock cooling.

7. If MD gauge variation is suspected, the die and air ring rotation should be stopped, a stub roll of film made and then cut open. At one point, the gauge should then be checked down through the layers of film. Lay flat web width can be checked at the same time. Non-contact thickness gauges will indicate MD gauge variation as cyclic average changes.

Extruder Unit

- **Screen Pack**

1. The use of heavy screen pack can result in improved film quality.

2. Excessive pressure above normal pressure (2000 to 3000 psi) indicates that screen pack needs to be changed.

3. Keep good records of when screen packs were changed and have operators frequently refer to them.

Extruder Unit

Breaker plate

- Breaker plate should be long enough to ensure that no melt will leak out.

Pressure valve

1. Method of varying internal pressure and have powerful effect on melt temperature. The pressure gauge should indicate pressure in the 70 to 350 kg/cm2 range.

Adopter

1. Maintain the specified temperature in the adopter using automatic system or manual procedure.

Die Unit

1. Control the temperature of the die
2. Control flow uniformity through die.
3. Melt distribution can be improved by lengthening and/or increasing the number of spiral grooves.
4. Die temperature should be same as melt temperature,
5. The die gap to be maintain between 0.5 to 3 mm
6. Use rotating dies to randomize transverse film gauge variation in the bubble.
7. Die must be cleaned and free from nicks, scratches, or other deformities.

Die Unit

8. Die must be leveled in all direction after the adopter has been tightly bolted.
9. Die must be plumped from the center of the nip roll for vertical centering.
10. Adjust the die at appropriate level by adjusting bolt.
11. Deposits should be cleaned from the top of the die with a brass shim stock inserted between the die lands.

Air Rings

1. The blown up ratio is equal to 0.637 times the ratio of blown film width to die diameter.

2. Ensure uniform air flow over the entire lip.

3. Once the process is started, first adjust the lay-flat width to the specified value. The screw rotation speed shall be set to the predetermined speed and the amount of air to be introduced into the bubble shall be adjusted. Then the film thickness shall be next step.

4. An air ring should be machined as precisely as the die and securely mounted parallel and concentric to the top if the die. When a die is cleaned, the air ring should also be cleaned of dirt carried in the cooling air. Blockage of the air ring causes gauge bands. Some air rings are mounted slightly above the die face with an air gap between the ring and the die, while others are placed on a flame retardant gasket directly on top of the die with no air gap.

Bubble Cooling and Stabilizing Unit

1. The recommended frost line height is 20 to 48 cm above die.

2. The inside diameter of the air ring is about 1.25 mm greater than the die diameter.

3. Air passing through the air ring must be clean. Filters on the inlet of the system must be cleaned or replaced frequently to keep the system trouble free.

Bubble Cooling and Stabilizing Unit

4. The installation of 500-watt floodlights in the film line area helps make the frost line fully visible to the operator. The lights should be mounted just above the usual frost line height, at least 30 inches from the largest bubble blown and aimed down through the frost line area towards the center of the bubble. The lights should beturned on during start-up for die and air ring adjustment or frost line check during production. The lights must be mounted carefully; if they are too close to the frost line and bubble, their heat can result in gauge bands.

Bubble Take-off Unit

Blown film tower

1. Film appearance should first be defined before being discussed. The term includes haze (clarity), gloss (reflectance) and general appearance (no imperfections in or on the surface).

Guide bars

1. It should not vibrate from unequal air distribution or too high an air velocity.
2. It should support the bubble.
3. It should prevent the bubble from swaying by means of one or more pairs of guide bars.
4. The guide bars are generally set parallel or right angle to each other.
5. Gusset blades must be aligned.

Bubble Cooling and Stabilizing Unit

Collapsing frames

1. Collapsing angle should be kept less than 11o.
2. Collapsing frames must be aligned.
3. The main nips must be centered over the die. The center of the die, bubble and main nip rolls must be in alignment with one another
4. Bubble stabilizer bars must be centered. Bubble stabilizer bars should be mounted so they can be adjusted symmetrically about the center line of the bubble.

Bubble Cooling and Stabilizing Unit

Nip rolls

1. Nip rolls must be leveled.
2. The tension in the film should be kept to a minimum.

Width measurement

1. Optical sensors

Gauge measurement

1. Snap gauges, infrared technology

Oscillating haul-off

1. Oscillating at 360o to 720o. Eliminate need of rotating dies.

Film Winding Unit

Surface treater

1. The corona discharge treatment equipment is made up of a high frequency generator, an electrode, and a treater roll.

2. The wetting tension of PE film and PP film that have not been surface treated is around 30 to 35 mN/m. The tension appropriate for printing on these kinds of film is said to be normally around 40 to 45 mN/m.

3. Treated film surface can be checked by measuring the wetting tension of the film surface. The wetting tension is an indication of the wettability of a solid surface.

5. Normally, wetting tension of a film that is not surface treated is around 30 to 35 mN/m compared to a treated film which has 40 to 45mN/m.

Guide rolls

1. Rolls can have non-slip coatings.

Feed roll assembly

1. Maintain constant and controlled tension.

Film winders

1. Surface winders are used when the diameter of the film roll exceeds 100 mm.
2. Check web tensioning devices regularly.

Web slitter

1. Adding simple roll doffing equipment gives the operator greater control in removing the roll of film from the winder and placing it intact on a pallet or in a carton.

General Instructions

1. Check the safety devices at place and operational.

2. Prepare accident prevention program.

Write down following instructions

- Startup Instructions
- Shutdown Instructions
- Cleaning the Extruder
- Prevention check list

Conclusions

- The material consumption, energy consumption, throughput / turnover and product quality are major factors for competitiveness for plastic film manufacturing units.
- Industry wide, there is large variation in performance outcomes measured in terms of above factors. The same to be confirmed by benchmarking analysis.
- The cause and effect analysis done for blown film extrusion process through ‘fishbone diagram’ reveals that technology apart, production processes practiced at company level are main factors.
- The setting of benchmarking to improve practices is difficult but not impossible. However, if it could be set to average levels, it results in competitive outcomes. .

Forward Path

- The best practices mentioned in this presentation are general in nature.
- Company level best practices could be developed and practiced to achieve benchmark targets in future

Thank You