MANUFACTURE OF POLYETHYLENE FILM

Project report

submitted by

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as a partial fulfilment of the

B. Tech. course on

I6th Dec I980

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DEPT. OF POLYMER SCIENCE AND RUBBER TECHNOLOGY

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A C K N O W L E D G E M E N T

In preparing this report I got innumerate help from so many sources.

Dr. Joseph Francis, Professor and Head of the Dept. of Polymer Science and Rubber Technology, University of Cochin, is really an encouragement and many thanks for him. I must thank Dr. K.A. Jose, Joint Director, Common Facility Service Centre, Changanacherry, for the fruitful discussions about the topic and for the arrangements He made for the industrial visits. Mr. K.E. G eorge Lecturer, Dept. of Polymer Science and Rubber Technology, University of Cochin, was always an encouragement. Being the project guide I found his service really beneficial and I acknowledge his valuable guidance.

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I. INTRODUCTION

The present scheme envisages the production of low density polythene tubular film by the extrusion process using an extruder. The raw material is LDPE granules and is available indigeneously. Machineries are also being manufactured within the country.

The largest single outlet of low density polythene is the film sector, accounting for 70 to 80% of the total low ~~dne~~ debsity polythylene sonsumption.

LDPE film by far is the most widely used packing material next only to paper. Over the years, LDPE films have found new markets and have increased their share in traditional markets. The vast popularity of LDPE films is due to its unique blend of properties, difficult to find in any other packaging material.

Some of the outstanding properties of LDPE films are clarity resistance to tear, good impact strength even at low temperatures puncture resistance, permeability resistance to most gases and liquids, non-toxicity, excellent yield, heat sealability, printability and ease of conversion into a variety of sizes. Its properties are compared with paper, its main competitor in the packaging field, as follows[I].

Table I. Comparison of the properties of the paper and LDPE film

Property	Paper	LDPE film
Tear initiation strength	good	good
Tear propagation strength	good	very good
Impact tensile strength	poor	good
Wet strength	poor	as dry
Elongation at break	almost none	very good
Stiffness	very high	low
Printability	very good	medium
Dimensional stability	very good	medium
Weldability	none	very good
Impermeability to water and gas	none	good
Bondability	very good	good
Foldability and Creasibility	very good	poor
Working properties on machine	very good	medium

For the production of polyethylene films, an extrusion process was developed in 1946. The chill roll casting method was developed two years later. The latter has better gloss and transparency than the extruded grades available. But it was unsuitable for bag making purpose because of a serious tendency to block. A year later, a blown ~~film~~ tubular film was made available which could be converted into bags although its clarity was poor by today's standards. Initial applications were mainly confined to industrial packaging such as covers for equipment packed inside wooden crates, the packaging of electrical resistors and as drum liners. The development of packaging for fresh produce gave a boost to the use of polyethylene film because of its combination of visibility and high strength. When, eventually, high clarity grades of polythene film were developed, new markets opened up in the fields of display packaging such as textiles, woolens, soft toys and similar items. During this time polymer cost were steadily falling and eventually polythylene film becomes the cheapest transparent film available. Today, one of the largest tonnage outlets of polythylene film is the heavy duty sack for fertilisers, peat, polymer granules and various other chemicals. The strength of polythylene is exemplified by the fact that a sack for 50 kg of fertilisers has a thickness of only 200 µm.

Packaging forms by far the largest outlet for polythene film and it is worth considering why. Packaging is not at all easy to define ~~by on~~ but one fairly concise definition is that, "packaging must protect what it sells, and sell what it protects." Packaging has, therefore, to supply both protection and sales to the product being sold. Polythylene films are able to carry out both these duties very effectively.

The tubular film, which is produced here can be made into rolls or bags for sale. This scheme is based on the production capacity of 108 tons of film production per year on a three shift basis and working 300 days in an year.

****

II. LITERATURE SURVEY

Some recent studies conducted by Richardwood[2] has established new relation between the ~~mmax~~ mechanical and optical properties of polythylene film to the output rate and blow ratio. A good coverage of the relation between film properties and processing conditions is also given by A.B. Glanvill.[3] Someof the important observations relevant to our study are summorised below.

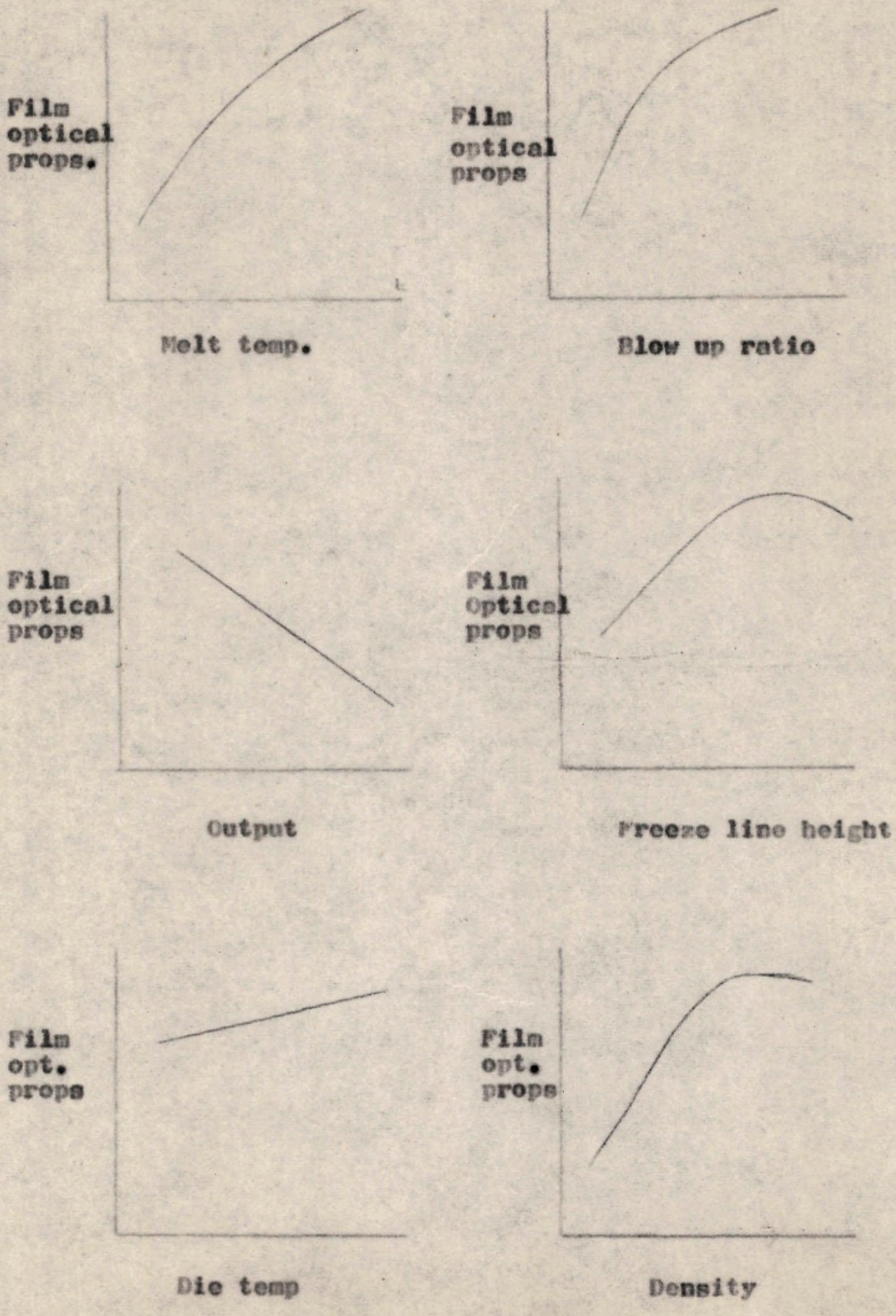
I. Surface and optical properties

The two major types of optical irregularity in polythylene films are caused by

(i) Surface irregularities resulting from melt flow phenomena and

(ii) Crystallisation behaviour

During the film processing operation there will be a change in the texture of the surface of the melt. The reason is a decrease in the depth of the extrusion defects and an increase in their length and breadth as the melt is drawn lengthwise and sidewise. As long as the polymer remains molten, the overall magnitude of the defects will decrease under the influence of surface tension. Thus as the freeze line height is increased the haze will diminish, but at the same time as this is happening the opposing effects of slower cooling times on the size of the crystallites will also operate. These effects are shown in fig. 2.I.



Effect of different variables on
film optical props.

2. Mechanical properties

Here the choice of the appropriate polymer is particularly important in achieving the desired end properties and many compromises have to be made. For eg, in the development of intermediate density polythylenes the flow properties have been adjusted to give high clarity film and the density is increased at a sacrifice of toughness to give the required non-blocking characteristics. Use of additives also can affect processing behaviour.

When considering the mechanical strength of film the important factor is the likely durability of the film in service, and this factor is almost impossible to assess in a simple way. However, it is accepted that a reasonable simulation of the necessary properties can be obtained by measuring the three quantities - tensile strength, impact strength and tear strength. The effect on properties of the conditions prevailing in the actual drawing zone between the die and the blowing ring are important, but also very complex. Therefore it is only possible to deal with them rather specifically. There are six important variables.

a) melt temperature

b) film thickness

c) haul-off speed

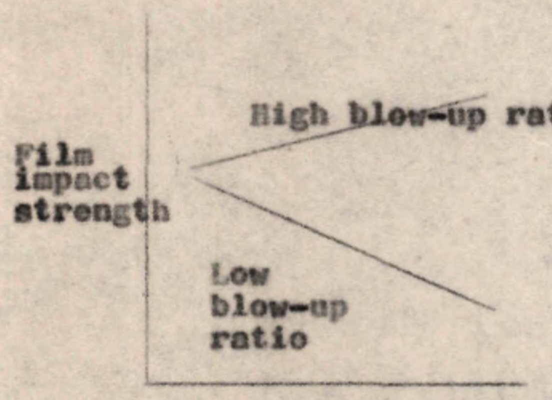
d) layflat width

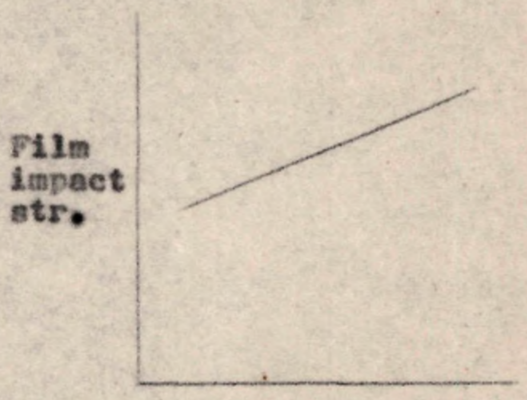
e) die gap and

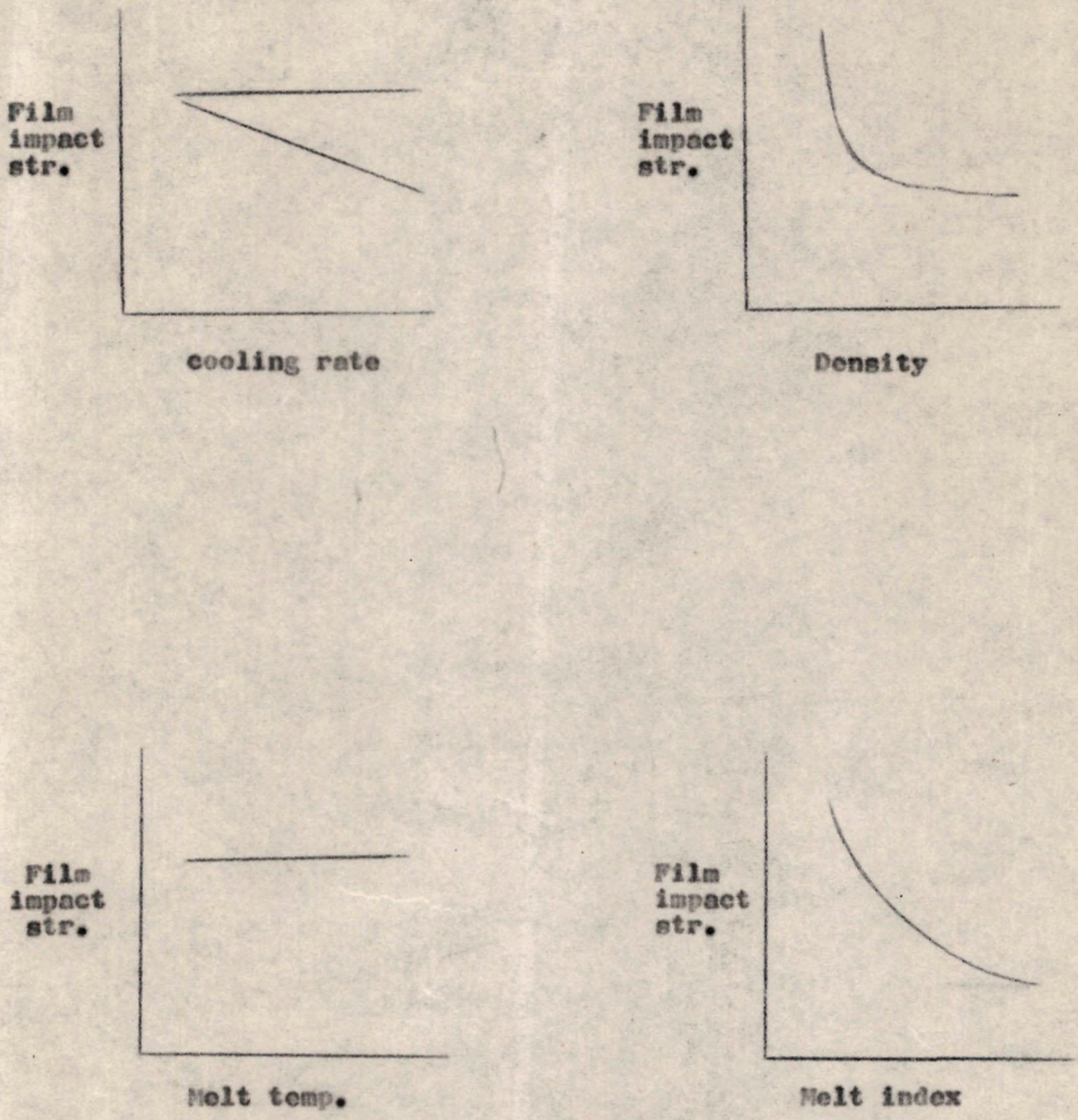
f) freeze line height

2.I Impact strength

For high impact strength the blow ratio should be between two and four with a high freeze line as is consistent with the bubble stability. The effect of keeping the freeze line high is accentuated at higher blow ratios and is more marked at the high melt temperatures; although it is possibly necessary to make a compromise with the haul-off speed. Impact strength is in fact considerably increased by higher haul-off speeds, but at these higher outputs, the bubble shape changes so that orientation in each direction instead of occurring simulatneously is now separated in time; the sideways one taking place later and just prior to the freeze-line. An increase of 20% in die gap was found to increase the impact strength by about 80%.





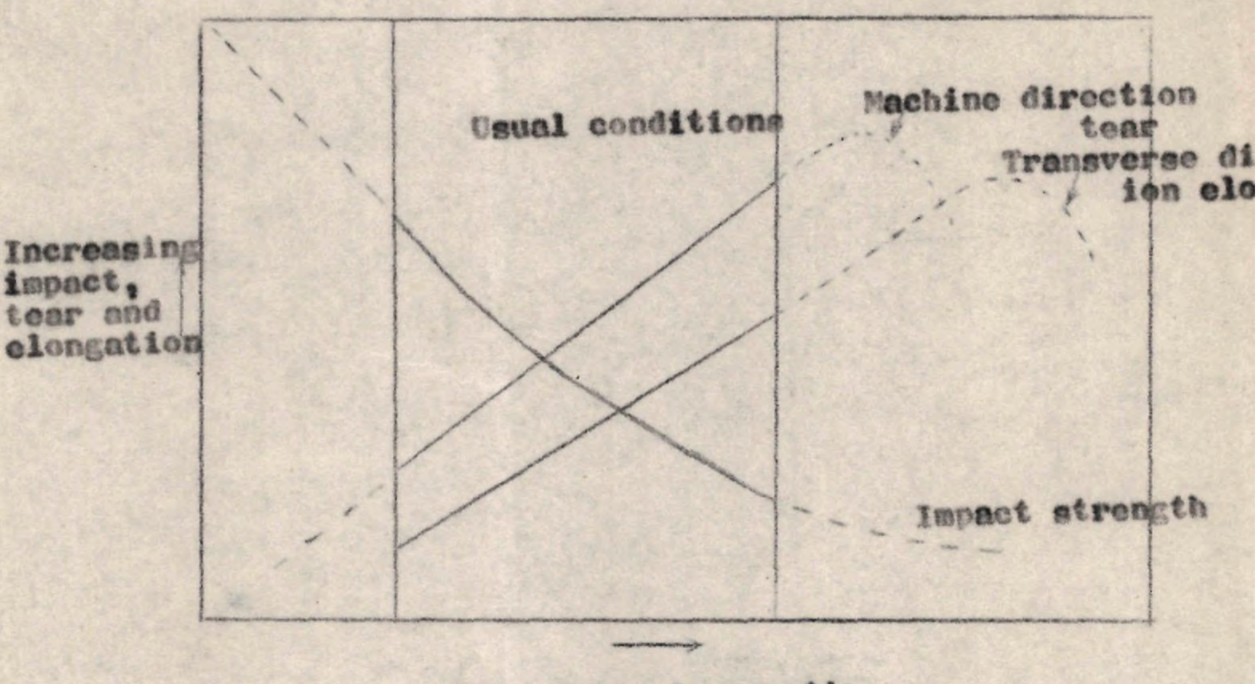


Effect of different variables on film
Impact strength

fig 2.2

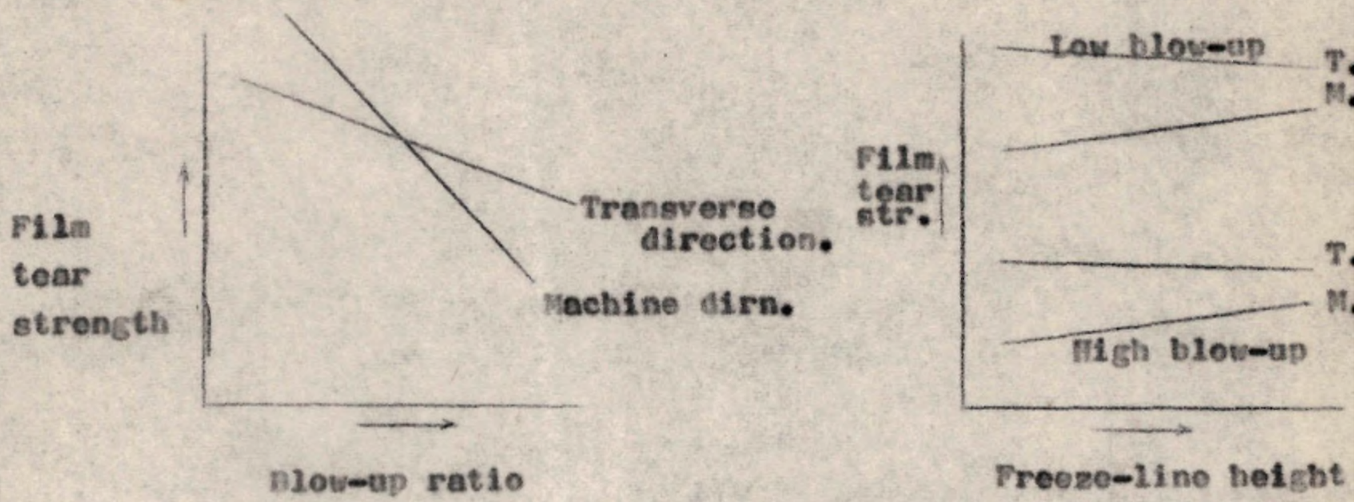
2.2 Tear strength

For high tear strength it seems well established that it is extremely difficult, if not possible, (for a given polymer) to obtain high impact strength as well as high tear strengths. Here, a lower blow ratio is preferred with high freeze line together with ~~high~~ a larger die gap. These rather conflicting findxings are also confirmed by I.C.I.'s work and ~~as~~ shown graphically in fig 2.3



Effect of transverse draw ratio on Mechanical properties of film

fig 2.3



Effect of blow-up ratio and freeze line height
on film tear strength

fig 2.4

2.3 Tensile strength

Usually tensile strength will decrease as blow up ratio increase in both directions. The effect can be shown in fig 2.5

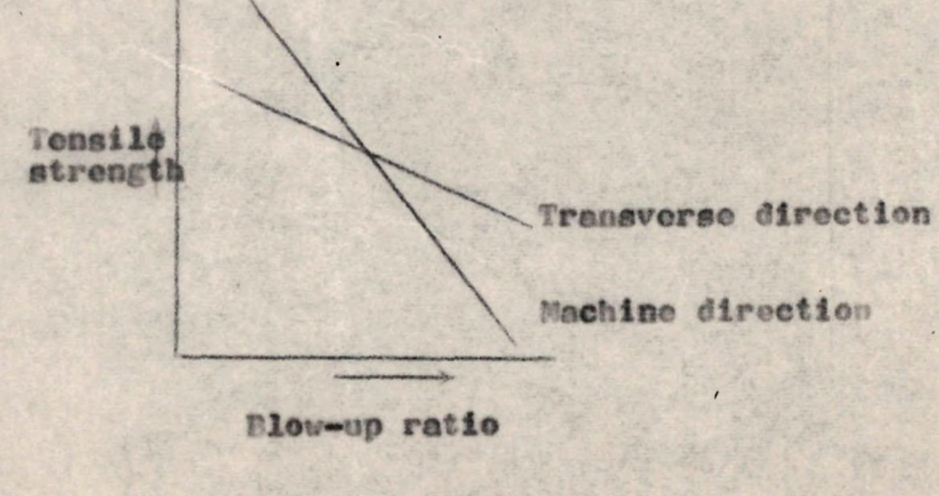


fig 2.5

2.4 Film blocking tendency

Film blocking tendency is of importance in polyethylene bag production. So the effect blow up ratio, wind up tension and rate can be shown in fig 2.6

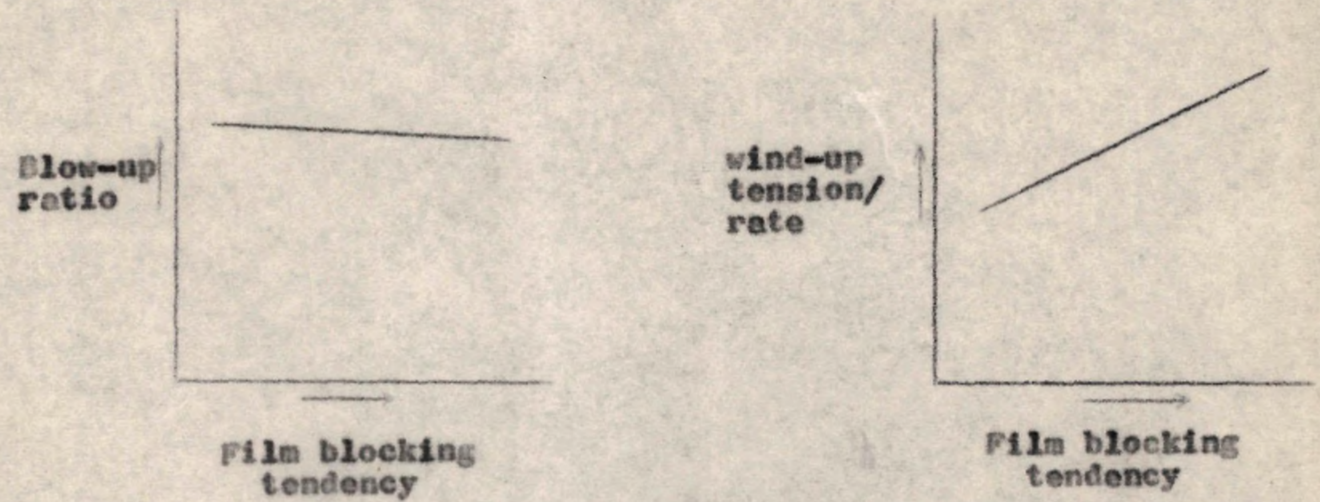


fig 2. 6

2.5 Film output

The effect of melt temperature, screw cooling and screw speed on output can be shown in fig 2.7

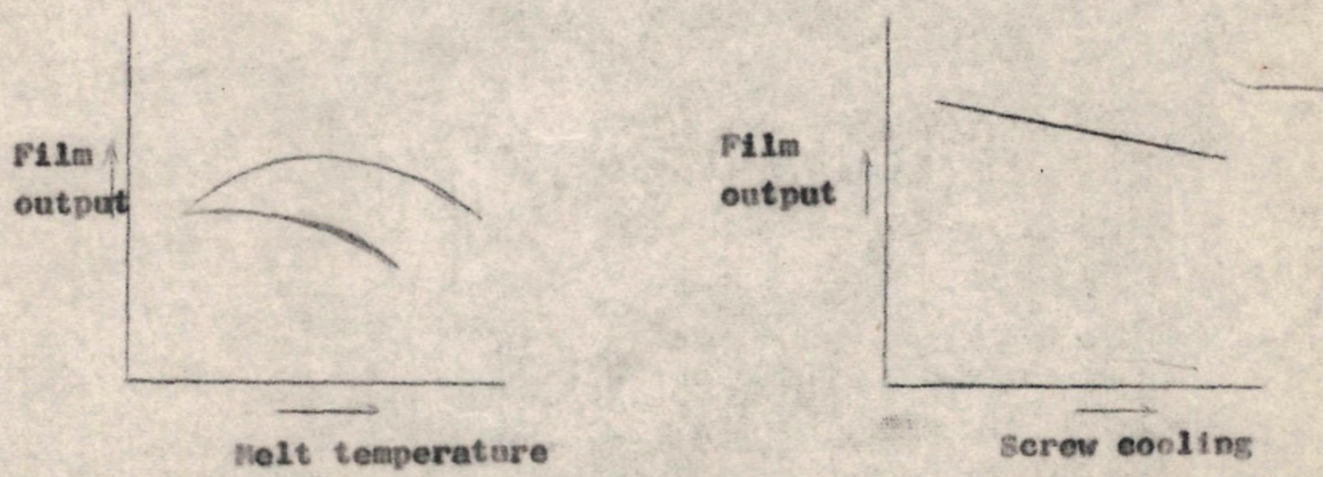


fig 2.7

The output of film can be calculated, if required, using the following formula.

$$Q = CpWtV$$

where,

Q = output (kg/hr or lb/hr)

C = Constant (6 in metric units and 26 in British units)

p = Relative density of the material at 20°C (68°F)

W = Width of film (circumference, if tubular) (cm or in.)

t = Thickness of film (cm or in.)

V = Linear output rate (m/min or ft/min)

3. Chill Roll Cast Film

The chill roll cast method is the second most used method of making polyethylene film, and is also widely used for polypropylene and for multilayer films of various polyolefins and other resins. In the chill roll cast method the polyolefin melt is extruded through a straight slit die, and dropped onto a highly polished plated roll, which is cooled by internal fluid circulation. The film solidifies on the roll, is stripped off either by another cooled roll or by a neutral roll, and is then trimmed, treated if desired, and rolled up.

This method makes clearer polyethylene film than the blown method. It also makes a very poor looking film by the blown process. The chill cast method generally gives better thickness control than the blown film method.

The chill cast process operates at much higher linear speeds than the blown film process, 1800 - 2000 fpm not being unusual. Blown film is generally limited to about 200 fpm, except for extremely thin (under 0.5 mil) film, which may operate upto twice that. High speed operation requires very sophisticated control equipment and, of course, the necessary cooling capacity on the rolls. As a result, a cast film line is much more expensive than blown film line, and in spite of the high speeds, the cost of a plant with the same total output is about the same for both methods.

4. Heat Sealing

The temperature of heat sealing is important in the case of polyethylenes. If the temperature is low the sealing will not be good and if it is high the film will stick to the sealing bar and hence block the process. So for bag making process the correct temperature has to be kept throughout the process without variation. The required temperature for different grades of polyethylene film can be given in the following table.

Basic properties and heat sealing characteristics of polyethylene

Effect of density and melt index

Density (g/cc)	Melt Index (g/I0 min)	Crystalline temp (°C)	Min. temp f satisfactor seal (C)
0.9I6	0.3	I05	II0
0.9I6	2.0	I05	I08
0.9I6	4.0	I03	I05
0.923	0.3	II0	I20
0.923	2.0	I09	II2
0.923	4.0	I08	II0
0.927	0.5	II4	I25
0.927	4.0	II2	II5

III. PROCESS OF MANUFACTURE

I. Description of the process

In this process a tube of molten polyethylene is extruded from a circular die and is expanded by internal pressure while it is still molten to form a very thin walled tube. It is then cooled, the tube is collapsed and slit to give a single film. It can also be rolled up without slitting, as tubular film.

While there are several variations of this process, the basic equipment needed can be well understood from fig 3.I. It shows a small commercial blown film unit.

The essential elements of this unit, following material flow from the extruder, are the die, air ring, gusseting frame, collapsing frame, nip rolls, treater, slitter, trimmer, lower nip rolls and winder. Each of these equipment will be discussed in this order, explaining major variations and reason for them.

I.I Blown film die

The film comes out of a tubular die will be of uniform thickness only if the slit is perfectly uniform. But usually it will not be the case and hence slight variation in thickness can occur at some parts of the film. So inorder to avoid it most of the modern blown film dies are rotated.

This variation can be kept to the point where, in itself, it is not objectionable. Then the thicker sections of the tube pile on top of each other in successive laps of finished roll an d produce hgih spots. When it is considered that a roll may con-

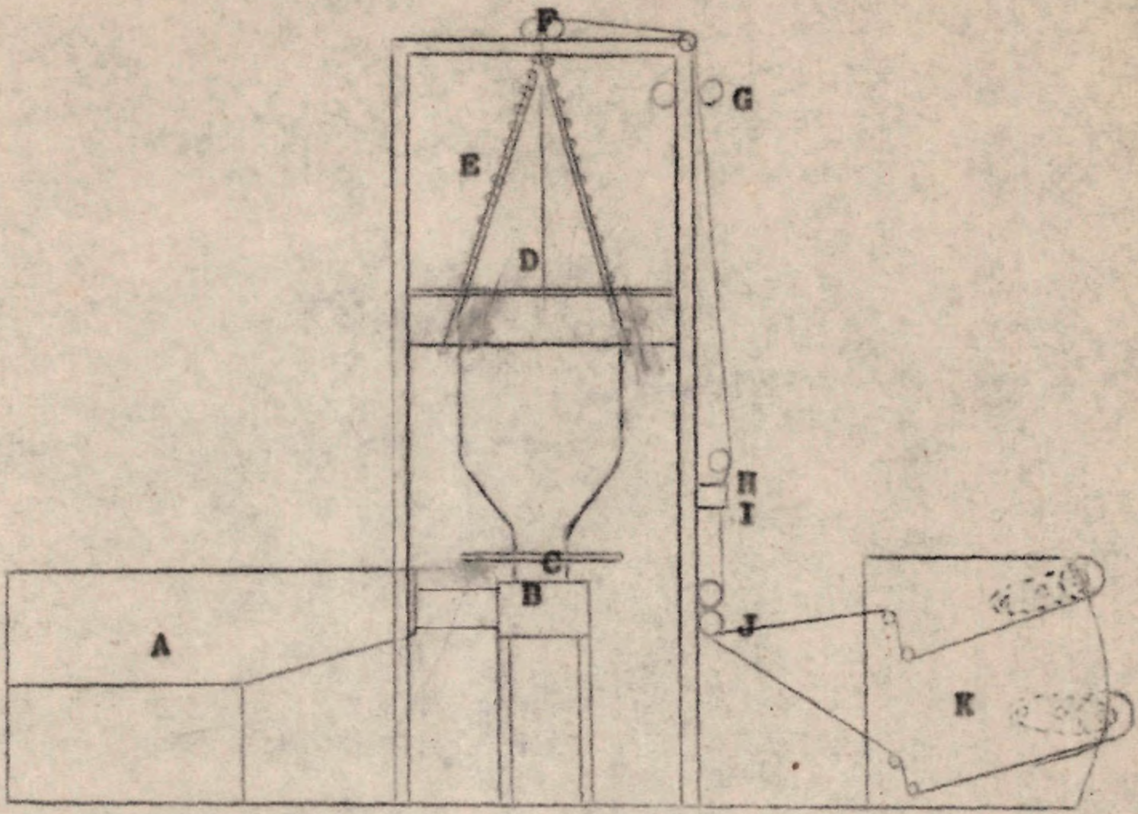


fig 3.1

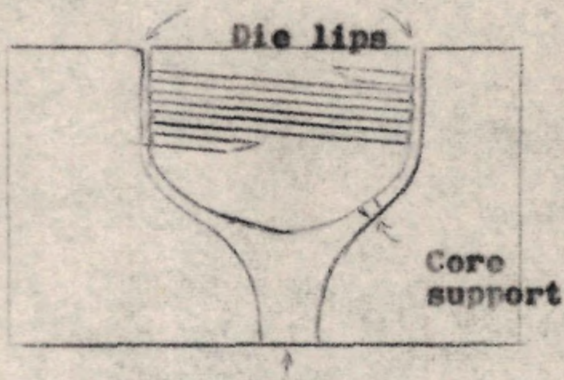
A - Extruder
B - Die
C - Air ring
D - Gusseting assembly
E - Collapsers
F - Upper nip rolls
G - Treater assembly
H - Wrinkle remover
I - Trimmer and slitter
J - Lower nip rolls
K - Winder

sist of 5000 or more layers of film, then it is clear that even a very small thickness difference may produce a high spot of serious proportions on the roll. The film on the outside of the roll is then no longer flat, but buckles as it is unrolled and becomes unmanageable in subsequent converting operations. If the die is rotated, the high spots do not come on each other, but are distributed evenly across the roll, making a perfectly smooth roll.

In order to make rotation possible, the melt entry must be through the bottom of the die, through a rotating joint. The most common die design for this purpose is shown in fig 3.2.

This is called a spider die because the centre core pin is supported by several (usually three) short arms which connect it to the main die body through the plastic flow channel. These arms are universally streamlined in shape, and as small as possible to avoid interference with polymer flow. In spite of this, the flow disturbance caused by them will cause an appearance defect in the film, unless provisions are made to smooth it out in the flow passage above the obstruction. One of the most successful means of accomplishing this is to put several shallow spiral grooves around the core pin in the part defining the narrow vertical flow channel. This tends to split the polymer flow into two parts; that moving vertically, and that mixing to obliterate the defects in the film.

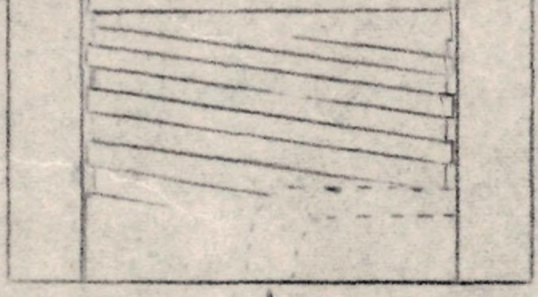
Another bottom fed die is the internal channel type. In this case the centre core is fitted directly to the base of the body. The polymer enters a central vertical channel in



Inlet

Spider type blown film die

fig 3.2



Inlet

Internal channel blown film die

fig 3.3

the core, which branches out into horizontal channels, which distribute polymer to the annular die opening(as shown in fig 3.3)

This kind of die has the advantage that the pressure of the polymer melt entering the die is not exerted over the entire core area, as in the spider type, but only on the much smaller channel area. This is important in the case of larger dies, where it permits the use of lighter construction. Dies of this sort also produce film apperance defects, where the adjacent flow streams merge, so similar means must be used to mix the flow.

Many other types of dies are used, including side-fed dies which cannot be rotated. These may be used on units where other means of distributing the high spots are used.

Very large dies, which may be used to make film 20 or upto 60 ft wide are generally not rotated. Such film is generally folded back on itself several times before making a roll, so there is no problem with high spot formation. Also, since this kind of film is used on construction projects or for agricultural uses, there is no problem with subsequent converting.

I.2 <u>Air rings</u>

Where the hot tube of plastic emerges from the die it is inflated upto the desired size by air pressure. A passage for air pressure must be provided through the die core for this purpose. At the same time it is cooled by a current of air blown on the outside by an air ring. This air ring also usually rotated, sometimes by direct connection to the die, and sometimes independently.

Air enters this ring through a stationary manifold which encircles the ring. Bafflings are placed inside for distributing the air evenly around the tube. Air exits at the inner face of the ring, which surrounds the plastic tube. The air ring has removable inner sections, which can be changed for use on different sizes of film. The horizontal air exit passage has a lip at the end which turns the air stream upward, so that it flows parallel to the tube rather than impinging on it directly. This is to prevent distortion and flattening of the tube, which is very soft and weak at this point.

I.3 Gusseting frame

When the film is to be used as tubular film to make bags, it is often desirable to gusset the tube. This means that instead of simply being flattened by the nip rolls, a portion of the tube has been tucked in so that it folds in between the main tube layers. Fig 3.4 shows an end view of a cut piece of tube A - without gusset, B - with gusset.

This makes it easier to open the resulting bag and also makes the bag easier to fill. Deep gussets may be used in wide film to make it possible to roll it up in a narrower roll. The gusseting frame consists of the means for holding and adjusting a gusseting plate on each side of the tube. This plate pushes a portion of the bubble in, at the same time that the collapsing frame is flattening it out, so that when it reaches the nip roller, the film layers are in proper alignment to produce gusseted film.

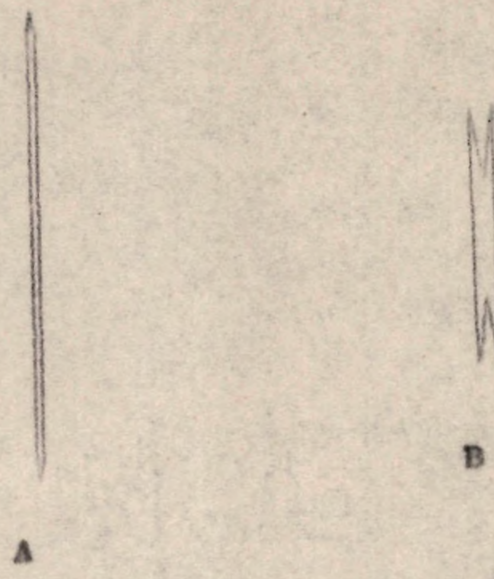
I.4 Collapsing frame

The collapsing frame pushes the sides of the bubble together so that they can be flattened by nip rolls without wrinkles. In the fig 3.I a series of small rollers is shown. This is a very common form. Another common form is a series of wooden slats, and perforated metal is also used. In case of collapsers that do not roll, it is necessary to have them very smooth to avoid scratching the film. Some kind of coating is common to reduce friction, but if the coating is too slippery there will be loss of bubble control. Fleuorocarbon polymer coatings, once quite popular, have been largely abandoned for ~~the~~ this reason. Various waxes are now more common.

The frame is so arranged that the angle between the two sides is adjustable to accomodate different tube diameters.

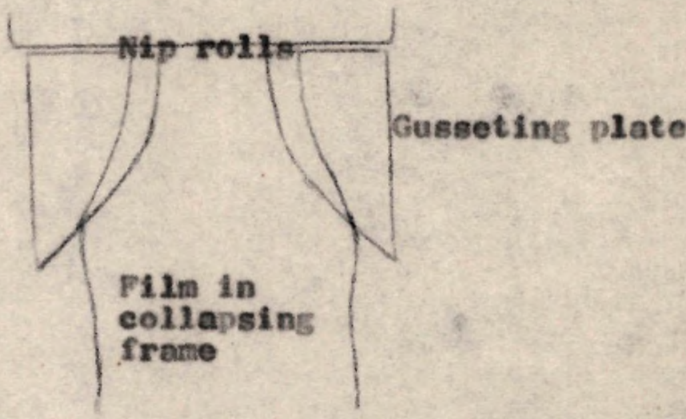
I.5 The upper nip rolls

The upper nip rolls pinch the tube together to keep the air in the bubble. ~~It should~~ The uniform size of the bubble, which is essential to good film width contr-ol is achieved by trapping a volume of air in the bubble. Air is added through the air inlet tube only to change the bubble size. Under proper conditions of operation the bubble size will remain constant for long periods without further air addition. This means that the nip rolls must be resilient enough to close the bubble completely, without at the same time pinching the edges of the tube so severely as ~~the~~



End view of tubing

fig 3.4



Gusseting plate

fig 3.5

to weaken the creases. The usual practice is to use one steel roll and one rubber covered roll, both of fairly large diameter, usually over 6". The nip rolls must have a means for adjusting the pressure between them to compensate for different film thickness, and should also be arranged to open for convenience in stringing up the unit.

The nip rolls regulate the film speed. Since average film thickness is controlled by balancing extruder output and film speed, it is necessary to have a variable speed drive on the rolls that will maintain a constant speed once the proper setting has been determined.

Some blown film units are equipped with a take-up at the nip roll level, but the common practice is to bring the film down from the nip to the extruder level as shwon in the fig 3.I, because this allows one operator to take care of both extruder and take-up.

One reason for having take up at the upper level is that this permits the use of a rotating take-up. The same roll smoothening function described under rotating dies can be accomplished by a stationary die and a rotating take-up. In this system the whole assembly of collapsing frame, nip roll and film take-up is mounted on a platform which can be rotated slowly about an axis directly above the centre of the die while the unit is running. While this becomes cumbersome on large units, it is quite satisfactory on relatively small ones.

I.6 Film treators

Polyethylene film cannot be printed in their natural state, so that any film intended for printing must be given a special treatment. This process is not specific to blown film, but it is a usual feature of a blown film line.

The usual method of treating polyethylene film is to play a corona discharge produced by a high voltage, high frequency electrical arc over the surface of the film. In order to do this the film is led over an insulated, grounded roller, while ahigh voltage is produced in an electrode close above the film. The high voltage ionises the air in the gap, allowing a corona discharge to take place through the gap. The electrical current doesnot actually penetrate through the film and the roll insulation, but these act as the insulation in a capacitor, so that the discharge occurs without direct current flow.

It is believed that the really significant effect of the treatment is to produce a crosslinked film surface which provides a stable anchorage for ink. Corona treatment is known to produce cross-linking, and if treatment is too severe, it may advance to the point where the plastic is no longer thermoplastic and cannot be heat sealed.

I.7 Slitters and Trimmers

While a good deal of blown film is used directly in the form of tubing any general purpose line must have provision for producing single thickness film, and slit tubes of various configurations.

When single films are required, the tube is generally made slightly oversized and the edges trimmed to remove the edge folds. Other modific+ations are U-tubing, which is made by cutting through both tube layers at one location, and J-tubing, which cuts through the tube layers at different locations.

I.8 Lower nip rolls

A lower nip is not essential to the operation of the line, but it generally facilitate slitting and trimming operations by providing a means of tension control independent of roll winding tension. The lower nip rolls are similar to the upper and are driven by a variable speed drive, the speed of which is controlled by a feedback mechanism from a film tension sensor somewhere between the two sets of nip rolls.

I.9 Winders

The winders on a blown film have two roll stations, so that the two layers of slit tube can be rolled up on separate rolls. The winders must be able to control winding tension accurately inorder to produce a good roll. Rolls may be wound with constant tension, which means that the tension on the film is the same when the roll starts as it is when the roll is finished. As the roll increases in size, the torque on the core increases if the film tension remains constant. This increase in torque may induce slippage of the film layers near to the core, and cause telescoping rolls. To prevent this, tension may be reduced as the roll grows to maintain a constant torque ~~winding may~~ on the core. On a large roll constant torque winding may be too hard near the core and too loose at the outside of the roll. For this reason it is common to control roll tensions with some degree of 'taper' intermediate between constant tension and constant torque.

I.10 Edge control and Wrinkle control

There are several ways by which film is kept wrinkle free and accurately aligned. Wrinkles may be removed by bowed rubber rollers, slat expanders or by edge rollers. Edge control, which assures the edge of the roll of film will be smooth is accomplished by having edge sensors, usually pneumatic, which activate rollers to correct any movement of the edge of the film away from its predetermined location.

I.11 Film thickness control

It has been customary in blown film manufacture to measure the finished film thickness with a micrometer, and to make take-up speed adjustments by hand inorder to bring it to the desired thickness. As the size of the units increased the waste produced by this method has become a serious cost. There are now film thickness gauges, generally based on the back-scattering of beta-rays, which may be placed against the film bubble to determine its thickness continuously while it is being produced. These gauges are at present still used in conjunction with hand adjustments, but by giving an earlier reading they reduce scrap. It is possible to connect these gauges to a control mechanism to maintain gauge automatically. This has been done in a few cases, although it is not generally considered economically attractive at the present time.

2. Quality Control Measures

The usual tests on plastic films can be described as follows. But all these tests are not required for films for a particular application. So we can select those tests required for our product But a factory of the present type neednot have all the required equipments for these tests. They can take a few samples and test it in some nearby institutions or else which have these facilities.

2.I Haze (ASTM D I003 - 6I)

This represents the proportion of a transmitted beam of light scattered by a piece of film. It can be measured by passing light rays through the film. It represents the milkiness or cloudiness in the film.

2.2 Gloss (ASTM D 523 - 62 T)

This is a measure of the amount of light reflected from the film when a light beam is directed at the film at an angle, and the result is reported in comparison with an arbitrary standard. Gloss represents the visual shininessor sparkle of the film.

2.3 Transparency (ASTM D I746 - 62T)

This measures the scattering of an extremely narrow slit beam of light by the film. It differs from haze mainly in the dimensions of the light beam and its method of measurement. It is reported as percentage of incident light that is not scattered, absorbed or reflected . Since the slit is extremely narrow the value depends on the position of the film, so the film is rotated during measurement and the transmission at different film positions is recorded. Maximum and minimum values are usually reported.

2.4 Dart drop test (ASTM D 1709 - 62 T)

A sample of film is clamped firmly in a circular holder held horizontally, and a small dart with a spherical head is dropped on the film from a standard height. Drops with varying weights are made until that weight is found which has an equal chance of breaking or not breaking the film.

2.5 Printability (Commercial Std. 227-59, U.S. Dept. of Commerce)

The evaluation of the quality of the special treatment for printability is the objective of this test. This is tested by applying a standard ink to the film. After it has dried, apply a piece of scotch tape to the ink, and pull the tape off. The percentage of ink retained is reported as the percent printable.

2.6 Adhesion ratio (ASTM D 2141-63T)

Pressure sensitive tape is applied to the film under standard conditions and the force required to peel the tape from the film is measured.

2.7 Wetting tension (ASTM D 2578-67)

In this test the minimum surface tension of the liquid required to wet the film is measured.

2.8 Gas permeability (ASTM D 1434-63)

In this procedure a shallow tray filled with calcium chloride is covered with polyethylene film, and the film is carefully sealed to the tray by the use of a special wax. The tray is weighed, placed in an atmosphere of controlled high humidity, and the weight gain is checked periodically.

2.10 Heat seal strength (Commercial std. 227-59, U.S. Dept. of Commerce)

Samples of film heat sealed by a hot bar are tested in a tensile tester and the strength of the seal is reported as the percentage of film strength.

2.11 Elemender tear strength (ASTM D 1922)

A special shaped sample of film is clamped into the machine, slit part way through, and then torn apart at the slit by means of a pendulum arrangement. The energy absorbed in tearing is measured by the reduction in pendulum swing.

2.12 Blocking

This is done by placing the films without parting them between two flat plates, taping one piece of the film to one plate and the other to the opposite plate, and measuring the force required to part the plates.

3. Utilisation of scrap

By-products, as its name defines is not formed in this process Anyway a part of the film, which may came to about 3-5% of the processed material, will become scrap. This is happening due to the wastage occurring when we want to change the gauge or width of the film produced. This can be sell to nurseries, after slitting it to films of very small width (2-3 cm), for budding purposes. But usually they are reproduced into granules with the help of special equipments. For this first the scrap film obtained is cracked to small pieces in a cracker. The cracked material is then extruded as strands into cooled water, where it gets cooled and solidified. It is then cut into small granules by a cutter. This can be again used to make films by maxing it with fresh granules. Upto 10% of the reprocessed material can be added to the fresh granules without any problem to the product. Anyway it will be better to warm the granules to avoid the presence of moisture before mixing it with the fresh granules. By this way about 80 - 90% of the scrap can be reused.

4. Waste Disposal

About 0.5 - 1% of the raw material may become waste. This can be dumped in a small ditch outside the factory. This will not produce any foul smell or any other problems.

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IV. PRODUCTION REQUIREMENTS

I. Location

When selecting alternative sites for locatingg the factory three important considerations are to be kept in mind.

a) Factory is relatively immobile

b) Impact of plant location on operating cost and profit are considerable

c) Building occupancy cost are both large and relatively fixed

Further essential requirements are

a) Proximity to the market

b) Proximity to raw materials

c) Facilities for transportation

d) Availability of skilled and unskilled labour

e) Availability of power and water

Since the main market of the production is among industrialists and businessmen the plant can be located near to a city. Sub-urban areas of Cochin will be an ideal place for this factory. The main consideration in selecting this factory site is the nearness to the market. At the same time the raw material suppliers' agents are also available here. The requirements of skilled labours also will be easily met here. Availability of power and transportation facilities are also best here. So a building of about I000 ft^2 can be rented from some nearby industrial estates.

2. Requirements of main raw materials

The total estimated production per annum including process losses is I07 MT. LDPE granules is available in the market at a price of Rs. 2I per kg.

3. <u>Machinery selection</u>

The selection of machinery is important since maximum utilisation of machinery gives better return for the money spent. The selection of each machinery is based on the following considerations.

(i) The estimated capacity.

(ii) The accepted standards and dimensions of the product

(iii) Its effect on utilisation of all other machinery.

Based on these the following machineries are selected for the production of I07 MT of LDPE film per annum on three shift basis.

3.I. Blown film plant consisting of:

3.I.I. 45mm thermoplastic extruder fitted with 5.5kw, I440rpm, 3phase, 50cycles A.C. varidrive gear unit having a speed range of 30/90 rpm.

3.I.2. Control cabinet consisting of 6 energy regulators with contactors, indicators, etc.

3.I.3. Two dies 3" and 8" and two air cooling rings.

3.I.4. Take up unit: consists of 32" long nip rolls (one rubber and one ebonite roll) driven by 0.I8 kw, D.C. infinite varidrive with a.c. rectifier and speed control switch.

3.I.5. One blower fitted with 0.74 kw motor, 2880 rpm, 3 phase.

3.I.6. One compressor fitted with 0.37 kw motor, I440 rpm, 3 phase.

3.2. Automatic bag making machine: 36" size, with a capacity of 40/60 bag per minute and working on a 0.37 kw motor, 3 phase It will have a heater of I500 W, 250 V.

In addition to the above machinery the following are also essential.

Weighing balance :- A 50 kg dial balance for checking bulk arrivals of raw materials and weighing finished film rolls and bags.

A water pump of 0.5 hp is also required for circulating the water for cooling.

A separate transformer is not required for the proposed plant since the installed power requirement is only about 10 kw.

3.3. Terms of-purchase of machinery

a) Quotations are made and satisfactory quotations are confirmed.

b) Price quoted are exclusive of packing, transportation costs, sales tax, excise duty, etc.

c) 30% of the price should be paid in advance and the remaining at the time of purchase.

d) Purchaser has the right for inspecting the machinery.

e) Supplier possess the right for cancellation, changing delivery time and price due to unforeseen reasons.

f) Warranty against manufacturing defects is assured.

g) Liabilities passes on to customer immediately after despatch and shortages should be notified within one week.

4. Manpower Requirement

The total manpower requirement are classified under the following heads

a) Administrative staff

b) Labourers

4.I. Administrative staff

The head of the administrative staff is the manager who handles the overall management of the factory. He should be a technologist as well so that the additional salary incurred on a separate technologist can be eliminated. A clerk cum typist and a peon also has to appointed for helping the manager. Both of them can be appointed in the general shift.

4.2. Labourers

Labourers are involved in the actual production operation. For each shift an experienced machine operator is required. Two helpers are also required to assist him in the production.

Job description	Total staff/ shift	No. of shift	Total staff/ shift
Machine operator	I	3	3
Helpers	2	3	6

5. Utilities

The utilities required are water and electricity.

5.I. Water:- The main use of water here is for cooling the feed section of the extruder screw. Since it is not consumed in any way we can recycle the water. For this purpose two tanks having a capacity of about I000 litres are required; one in the ground level and the other at a height of about I2 ft from the floor. Water is always flowing from the top tank to the bottom through the extruder. This is repumped from the bottom to the top using a 0.5 HP water pump. About I00 litres of water will be required for the amenities of the employees per day.

5.2. Power;- Total power consumption is as follows;

45 mm extruder	-	5.5 KW
Blower	-	0.74,,
Compressor	-	0.37,,
Motor for take-up	-	0.37,,
Bag making machine	-	I.50,,
Water circulating pump	-	o.37,,

Fan, light, etc.	-	I.oo KW
Total	-	9.85 KW

Power consumption per hour (assuming 0.8 as power factor) = 8 KWH (approx)

Power consumed per day = I92 KWH

Power consumed per annum = 57600 KWH

Power cost per annum @ Rs. 0.165/KWH = Rs. I0000(approx)

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V. M A R K E T S U R V E Y

I. Users Customers Analysis

For quite a few years packaging has been the largest volume use for LDPE and it is one of the fastest growing industries.

I.I. Fresh produce

The first large scale civilian use of polyethylene film was in the packaging of fresh vegetables. The moisture resistance of the film reduces moisture loss from the vegetables, thus decreasing the weight loss ~~from the vegetables~~, in shipping and keeping the produce in good condition longer. The relatively high oxygen and carbon dioxide transmission of the film permits the vegetable to continue a low level of respiration in the package which is essential to retard spoilage. For some vegetables the barrier properties of polyethylene film are too strong, so that the best storage condition require some perforations in the bag. The use of polyethylene for packaging produce is now so widespread that most of the vegetables on any modern vegetable counter will be packaged in polyethylene film.

I.2. Frozen foods

Frozen vegetables are also very often packed in LDPE bags. LDPE has a remarkable ability to remain tough and flexible even at low zero temperatures of food freezing. The plastic bags quite adequately serves as the sole container for the frozen food, and a large quantity is sold for this purpose, usually in the large size economy pack. In some cases plastic bag is used inside a carton, which serves mainly as a means of display.

Prepared frozen foods are also often wrapped in polyethylene film.

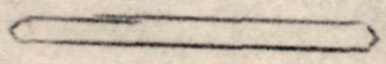
I.3. Bakery products

Bread and other bakery products are also mainly packaged in polyethylene film. Smaller amounts of LDPE bags are also used for other bakery products. The advantages of the bag over the wrapping are its ability to be opened easily and its reclosable features.

As with fresh vegetables, polyethylene retards drying and keeps bread fresh longer than other packaging methods do. The polyethylene bags are very resistant to breakage, practically eliminating loss due to package failure.

I.4. Soft goods

Soft goods packaging is another field taken over almost entirely by LDPE bag packages. Soft goods compass clothing, shirts, ~~sweets~~ sweaters, sheets and blankets. These are now commonly packaged in one ingenious bag, which is essentially self closing when filled. The bag is made from a piece of tubing with a cross section shaped like that in fig 5.I



Cross section of a film for making
one kind of self-closing bag

fig 5.I

The bags are made by sealing and cutting across the tubing, making a side seal bag. To fill the bag the inner flap is pulled out, the article inserted, and then outer flap is pulled over the end of the article. The pressure of the contents, which must, of course, be a single compressible article, then holds the inner flap against the outer flap making a closure. Generally a strip of pressure sensitive tape is put across the two flaps just for safety, but even without that, it is quite a secure closure.

The polyethylene bag is clear enough for the contents to be seen, flexible enough for them to be felt to some extent, tough enough for them to ~~be felt t~~ withstand rough handling, and serves to protect the contents against soiling.

I.5, Garment bags

Closely related to soft goods packaging but is a separate category, is the laundry and dry cleaners shirt and garment bag. Very thin LDPE film is used for this purpose, the usual garment bag film is 0.3 mil thick. This thinness can be used because the application only requires a single short time use. The extreme thinness of the film make it very inexpensive. This is really the only application where cost becomes a major consideration in the use of plastic film. For this application of polyethylene film is the cheapest material that will do the job; in addition it is better than paper because of its transparency, toughness and easy handling.

An extremely thin film bag is too limp to be handled like a paper bag. This problem was solved by producing the bags in a continuous roll, with easily torn perforations between the bags. This ~~problem was solved by producing the bags in a continuous~~

roll is supported on a dispenser which hangs above a hook supported from the floor.

I.6. <u>Shrink wrap</u>

Carton over wrap is another large and growing field of polyethylene film. In this application the primary package is a rigid perforated carton, and the polyethylene is wrapped over it to protect it from dirt and moisture, to give it gloss and often to hold it shut. This is done by wrapping a sheet of film over it and sealing the edges together on the bottom or ends, much in the same way as other sheet wrapping materials are used. In recent years this method of wrapping has been replaced to a great extent by shrink packaging, where special shrinkable film is used. The package is generally placed between two sheets of film, and the edges are heat sealed all around, giving a rather loose fitting wrap. This is then run through a shrink tunnel, where hot air or I.R. heaters heat the film to its shrink temperature, where it then shrinks up into a neat tight fitting wrap. In this application a certain amount of polypropylene, in addition to LDPE, is used. Shrink packaging is used in to overwrap field and to an increasing extent in produce wrapping and other types of wrapping.

I.7. <u>Agricultural applications</u>

The polyethylene film greenhouses is quite widely used. It is inexpensive and produces interior conditions very well suited to a wide variety of crops. Tomatoes, for instance, are grown in considerable quantity under polyethylene.

These houses are generally of light frame construction and in cold areas will consist of a layer of polyethylene film both outside the frame and inside, having an air space for insulation. The green house may be heated by warm air distributed through polyethylene tubing ducts. In regions of heavy sunlight exposure a polyethylene film cover usually last only a season, but in northern countries where the summers are cool and short they may last several years. It is also possible to put an uv light inhibitor in the film to increase the life.

Polyethylene film also has many uses on the farm for temporary protection of materials and produce.

It is possible, for instance, to make a 'silo' that satisfactorily stores ensilage, simply by putting down a sheet of heavy gauge, polyethylene film, piling the ensilage on the sheet, and covering this with another sheet, sealing the edges by folding them together and covering them with dirt. Black film is necessary at least for the top sheet because light will spoil the ensilage. A silo of this sort will keep the fodder in good condition for an entire winter. It is inexpensive to make, and it may be placed near either where the crop is grown, or where it will be used, to reduce the handling.

Wire mesh coops for chickens and other small animals can be wrapped with polyethylene film to a great extent. The roots of dug plants and in many cases the entire plant are protected from drying by a polyethylene bag.

Polyethylene film is also used as a waterproofing liner for farm ponds and irrigation ditches to prevent water loss.

2. Present demand and sources of supply

The production of polyethylene film is directly related to the availability of polyethylene granules in India, since 70 - 80% of LDPE manufactured in India is used for the production of film. HDPE is also used in film production now-a-days. So the growth of film industry in India can be directly seen from the LDPE production in India which can be given as follows.

Installed capacity (MT)	Production (MT) of LDPE		
	'77	'78	'79
III,000	I9,296	32,700	73,889

The production of polyethylene film in the last three years can be seen as follows.

Years	Production of LDPE film (MT)
1977	I6,000
1978	26,000
1979	59,000

Now three of the LDPE manufacturers are situated in Bombay and one in Baroda. As a natural consequence the concentration of film industries are the highest in Maharashtra and Gujarat compared to other parts of India. Anyway unlike other industries most of the States have their own factories meeting most of their demand. In Kerala also about 55 units are registered as polyethylene film manufacturers with an installed capacity of about I900 MT in I989. So they have produced about I400 MT film in I979 which was insufficient to meet our demand. So presently the rest of our demand is being met by manufacturers from Tamilnadu.

The manufacturing units of polyethylene in Kerala with their installed capacity and the district in which they are situated can be given as follows.

LDPE Film industries in Kerala

District	No. of units	Installed capacity (MT)
Alleppey	5	I49
Calicut	7	2I5
Cannanore	7	48I
Ernakulam	9	240
Idukki	I	I
Kottayam	9	I66
Malappuram	o	o
Palghat	5	230
Quilon	2	90
Trichur	3	60
Trivandrum	7	27I
	55	I903

Ref: Kerala Small Industries Directory

3. Assessment of future demand and demand projections

The demand for polyethylene films has risen from 3,000 MT in the year 1958 to 60,000 MT in the year 1979 and this demand will rapidly pick up to reach more than 1,10,000 MT by the year 1983.

4. Prices and effect of changes in prices on demand

The present prices of LDPE powder is Rs. 21 per kg. The processing charge will come around Rs. 2/kg. Hence the cost of production of LDPE film will come around Rs. 23/kg. In the case of polyethylene film which is used for canal lining, as rain guards, etc the cost change may not cause much difference in the demand since no other choices are available in this field, other than plastic films. But the situation is entirely different in the case of packaging, which is the largest volume use of polyethylene film, where a number of other alternatives such as cellophane, glazed paper, waxed paper, kraft paper with inlaid layer of tar, etc are available. Eventhough polyethylene film has captured a good share of this market these materials are also used to a great extent. For example in the case of packaging paper still hold the largest share. So the increases in LDPE price, which is the determining factor in the price of film, may cause its departure from this field. But if by any chance a slight decrease in the price is possible it can conquer a large share of the still unconquered fields also, which will boost the production of polyethylene film.

Polyethylene bags is still competing with paper bags in textile and other retail shops. Here also the only advantage of paper over polyethylene film is its cheapness.

Anyway due to its special properties like transparency, toughness, attractiveness, etc this is ~~new~~ gaining more and more market now-a-days. Considering the trends in other countries we can assume that it is not far in our country also, these markets will be fully captured by plastic films evenif there will be trends of increase in raw material prices. In packaging about 75% of plastic films used is polyethylene film itself.

4. <u>Competitive situation and Export possibilities</u>

The internal competition is not so severe in Kerala since nearly all of the factories are small units and they are scattered all over the state. So each unit will be concentrating only on the surrounding market, since enough market is available there itself.

Now the main competitors in polyethylene film manufacture are from Madurai and Coimbatore. Since these units are of bigger capacity and also since the labour is slightly cheaper there they can produce the film at a slightly lower rate than in Kerala. Even then while considering the freight charges, etc, manufacturers of Kerala will have clear advantage over them. But the higher sale tax (8.8%) on raw material in Kerala compared to Tamilnadu and ~~Mysore~~ Karnataka (4.4%) is causing some problems to the factories in Kerala now-a-days. ~~So~~ Anyway the starting of a few factories for film production are bright ~~in~~ at present.

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VI. CAPITAL REQUIREMENTS

I. Fixed Capital

It is the sum of the expenses incurred on land, building, plant and machinery, other fixed assets and preoperative expenses. It should also include expenses incurred on office and fixtures.

Table - I

Item	Cost (Rs)
I. Plant and machinery	I,02,675
2. Other fixed assets	I9,000
3. Contigency	I2,I70
4. Preoperative expenses	7,000
Total	I,40,845

2. Working Capital

The working capital provides fund for a definite period of production depending on the time taken for the realisation of sales value. This is usually worked out for three months . Working capital includes raw material cost, manpower, utilities and other overheads.

Table - 2

Item	Cost (Rs)
I. Raw material	22,68,000
2. Wages and salaries	75,260
3, Utilities	II,000
4. Other overheads	32,600
Total working expenses per annum	23,86,860
Working capital	5,98,485

???????

VII. F I N A N C I N G P L A N

As the entrepreneur can't afford to take all the capital requirements from his own pocket he has to plan sufficiently early to raise the required capital. The financial institutions and nationalised banks are at help.

Some of the financial institutions and their provisions are given below.

I. Sources of Capital

I.I. State Small Industries Development Corporation

They offers machinery on hire purchase on a margin money deposit of 20%. Repayment starts after two years and should be complete within 7 years. It offers special concession to technically qualified persons. Interest rate is 7.5%.

I.2. State Financial Corporation

SFC offers financial assistance as cash to small and medium scale industries provide 85% of land, building, machinery, miscellaneous assets and contingency upto IO lakhs. Repayment starts by the end of second year and should be complete within IO years in I7 half yearly instalments. The interest in the case of specified backward areas is IO.25% and for other areas it is II.85%.

I.3. Commercial and Co-operative banks

Nationalised banks provide cash loans for machinery, Loans are given on 25% margin money and I2 to I6% interest. For working capital any amount can be taken. Repay period is 3 years.

I.4. National Small Industries Corporation

NSIC offers hire purchase facilities for machinery at 7.5% interest and the repayment period is 7½ years.

I.5. <u>The Industrial Development Bank of India</u>

IDBI gives financial assistance directly to industries upto ¾th of the capital investment so that the promoters contribution should not be less than 25%. Interest rate is I2%.

I.6. <u>State Govt Industries Departments</u>

Under Rural Industries Project Scheme Govt loans are available for machinery acquisition, upto 90% of the machinery cost at 6½% interest.

2. <u>Financing the Project</u>

Gross capital requirement of Rs. 6,39,330 can be raised as follows.

2.I. <u>Borrowing</u>

Machinery can be brought on hire purchase from NSIC AT 7½% interest. Rs. I,02,675

75% of the working capital is supposed to be taken from IDBI or any Nationalised Banks at I2% interest. Rs. 4,50,000

2.2. <u>Own capital</u>

The balance of the total capital requirement, ie Rs I,86,655 is contributed by the entrepreneur.

I. Borrowing:

Loan from NSIC		Rs. I,02,675
Loan from IDBI		Rs. 4,50,000

2. Own fund:

Preoperativeexpenses	Rs. 7,000	
Other fixed assets	Rs. I9,000	
Contingency	Rs. I2,I70	
Margin money for working cap.	Rs I,48,480	
	-------	Rs. I, 86, 655

	Total	Rs. 7,39,330

VIII. P R O F I T A B I L I T Y

The financial viability of the project can be gauged through the profitability. The following factors are examined in this case.

I. Level of operation and Break even point

Break even point is that quantity which if produced and sold will give neither a profit nor a loss

$$B.E.P. = \frac{F}{P-V}$$

where,

F = Annual fixed cost

P = Price of one kg of polyethylene film

V = Variable cost of one kg of polyethylene film

Total sales of the product	= 107 MT
Price per kg, P	= Rs. 25/kg

Total variable cost:

a) Raw materials	Rs. 22,68,000
b) Utilities	Rs. 11,000
c) Direct labour	Rs. 39,600
d) Distribution cost	Rs. 53,500
Total	Rs. 23,72,100

variable cost per unit, V = Rs. 22.16

Total fixed cost, F = Cost of production - Total variable cost

=Rs. 1,566,70

$$\text{Break even point} = \frac{1,56,670}{25 - 22.16}$$

= 55,180

So by producing 55.18 MT of polyethylene film per annum the factory can be run on a no-profit - no loss basis. Further increase in production results in increase of profiet.

2. Rate of return on own capital

Own capital	= Rs. 1,86,655
Net profit	= Rs. 72,620
Rate of return on own capital	= 38.9%

3. Rate of return on capital employed

Gross capital	= Rs. 7,39,330
Net profit	= Rs. 72,620
Rate of return on capital employed	= 9.8 %

4. Profit on sales turnover

Annual sales turnover	= Rs. 26,75,000
Net profit	= Rs. 72,620
Percentage of profit on sales turnover	= 2.718%

££££££££

IX. E C O N O M I C   V I A B I L I T Y

1. Ability to payback borrowed funds

(i) Interest commitments

7½% interest on loan from NSIC	= Rs. 7,700
12% interest on working capital from IDBI	= Rs. 54,000
Total interest to be paid per yr.	= Rs. 61,700

(ii) The term loan has to be paid back within the prescribed time. The payback period is kept within the minimum time possible to save interest. Of the total capital 25% is retained for personnel needs and 75% is used to payback term loan.

(iii) Payback time of term loan

Annual net profit	= Rs. 72,620	
Depreciation	= Rs. 16,100	
~~Less drawings~~	= Rs. 88,720	30
Less drawings	= Rs. 22,180	
Amount used for repayment	= Rs. 66,540	40
Term loan to be paid back	= Rs.1,02,675	
Time required to payback	= 19 months	

2. Payback period

Payback period is defined as the length of time required to get back the initial investment.

Initial investment	= Rs.7,39,330
Net profit per year	= Rs. 72,620
Payback period	= 10.18 years

&&&&&&&

X. ANEXTURES

Annexture - I

Fixed Assets

Item	Cost (Rs)
I. Plant and Machinery	I,02,675
2. Miscellaneous fixed assets	I9,000
3. Contingency	I2,I70
4. Preoperative expenses	7,000
Total	I,40,845

Annexture - IA

Plant and Machinery

Item	Cost (Rs)
I. 45mm blown film plant consisting of:	
a) 45mm thermoplastic ext-ruder	
b) Control cabinet	
c) Two dies and two air rings	
d) Take up unit	
e) One blower	
f) One compressor	70,000
2. Automatic bag making machine	20,075
3. Packing and forwarding	6,000
4. C.S.T. @ 4%	3,600
5. Freight charges	3,000
	I,02,675

Annexture - IB

Miscellaneous fixed assets

Item	Cost (Rs)
I. Erection and installation charges, electrical fittings, miscellaneous tools, etc	10,000
2. Offi ce furniture and typewriter	6,000
3. Water circulating pump, starters, etc	3,000
Total	19,000

Annexture - IC

Preoperative expenses

Item	Cost (Rs)
I. Travelling expenses	2,000
2. Postage, telephone, telegram and legal charges	2,000
3. Advertisement and printing	2,000
4. Establishment	1,000
Total	7,000

Annexture - II

Working Capital

Item	Cost (Rs)
I. Total raw material cost (Annex. IIA)	22,68,000
2. Manufacturing cost (Annex. IIB)	86,260
3. Other overheads (Annex. IIC)	32,600
Total working expenses (annual)	23,86,860
Working Capital	5,98,485

Annexture - IIA

Raw Material

Average capacity of the extruder	= 18 kg/hr
Average working hours per day	= 20 hrs/day
Average working days per year	= 300
Consumption of LDPE per year	= 1,08,000 kg
Cost of raw material per year @ Rs. 21/kg	= Rs. 22,68,000

Annexture - IIB

Manufacturing cost

Item	Cost (Rs)
I. Cost of utilities (Annex. IIBI)	II,000
2. Salaries and wages (Annex. IIB2)	75,260
Total	86,260

Annexture - II BI

Utilities

Item	Cost (Rs)
I.Cost of power @ 0.I65/KWH	I0,000
2. Working expenses for water supply	I,000
Total	II,000

Annexture II B2

Man power requirement

Post	No. of persons	Total Salary (Rs)
I. Manager	I	I,2oo
2. Clerk cum typist	I	500
3. Peon	I	300
4. Machinery operators	3	I,500
5. Unskilled workers	6	I,800
Total	I2	5,300

Annexture - II B3

Total Salaries and Wages

Item	Cost (Rs)
I. Total salaries and wages per annum	63,600
2. Benefits and allowances @ I8%	II,660
Total	75,260

Annexture IIC

Other overheads

Item	Cost (Rs)
I. Rent of the building	I2,000
2. Repairs and maintenance of the machinery @ 5%	5,400
3. Travelling and advertising expenses	2,000
4. Insurance (2% on fixed capital)	2,560
5. Stationery, postage and telephone	I,000
6. Repelletising charges (4% of raw material @ Rs.2/kg	8,640
7. Miscellaneous	I,000
Total	32,600

Annexture - III

Gross Capital Requirement

Item	Cost (Rs)
I. Total fixed capital requirement	I,40,845
2. Total working capital requirement	5,98,485
Total	7,39,330

Annexture - IV

Total cost of production (annual)

Item	Cost (Rs)
I. Raw material (Annex. IIA)	22,68,000
2. Utilities(Annex. II BI)	II,000
3. Personnel (Annex. II B3)	75,260
4. Overheads (Annexture II C)	32,600
5. Other fixed costs and interest on loans (Annex.IVA)	77,800
Total	24,64,660

Annexture - IV A

Depreciation and Interests

Item	Cost (Rs)
I. Depreciation	
a) Depreciation on machinery @ I5%	I3,500
b) Depreciation on other fixed assets and pre-operative expenses @ I0%	2,600
2. Interest on loan	
a) Interest on working capital @ I2%	54,000
b) Interest on estimated term loan @ 7.5%	7,700
Total	77,800

Annexture - V

Sales turnover &
Net profit

Item	Cost (Rs)
Total production of film and bags(giving I% for waste losses	I,07,000 kg
Gross sales realisation per year @ Rs. 25/kg	26,75,000
Less: Cost of production	24,64,660
	2,I0,340
Less; Distribution cost @ 2% (freight charges, etc)	53,500
Gross profit	I, 56, 840
Less: Income tax(@ Rs. 45000 for the first Rs. I00000 and 69% of the profit above it)	84,220
Net profit	72,620

XI. APPENDICES

Appendix I

Suppliers of raw material

I. M/s ICI (India) Ltd, Crescent house, Ballard Estate, Fort, Bombay

2. M/s Union Carbide India Ltd, Kasturi Building, Jamshedji Tata Road, Bombay.

3. M/s ACCI, I8, Strand Road, Bombay.

4. M/s IPCL, Petrochemicals P.O:, Baroda.

Appendix II

Suppliers of Extruder

I. M/s R.H. Windsor (India) Ltd, Plot E-I6, Road Thana Industrial Estate, Thana, Bombay.

2. M/s Boolani Engineering Corporation, 524, Sayani Road, Bombay - 28.

3. M/s Brimco Plastic Machinery Corporation, Plot No. 55, Govt Kandivili Industrial Estate, Charkop, Kandivili (west), Bombay - 67.

4. M/s Kolsite Industries, 3I, Shah Industrial Estate, Off Veera Desai Rana, Andheri (West), Bombay - 58.

Appendix III

Suppliers of Automatic bag making machine

I. M/s Babubhai Ambalal and Co., Kaiser Hind Building, 3rd Floor, Currimbay Road, Ballard Estate, Bombay - 38.

2. M/s Navel Engg (P) Ltd, Sambara Chamber, Sir Mehta Road, Bombay -I.

3. M/s K.S. Mechanical Engineers, 228, Industrial Area, A-link Road, Ludhiana - I4I 003

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