Chapter 4

Manufacturing analysis

1. Process analysis

1.1 Process description

1.1.1 Extrusion process [Choetkiettikul, 1996]

Flat film extrusion process is the principle of shaping a melt plasticated and homogenized in the heating extruder, consequently cooling and stabilizing plastic structure through chilled rolls. Next trim and wind it up as required width. For better understanding, such process can be split into significant steps as addressed below.

1.1.1.1 Material feeding Plastic resins are fed through feeding system from their bag or silos to hopper where plastic resins are weighed as production formula and then they subsequently fall down to the extruder barrel.

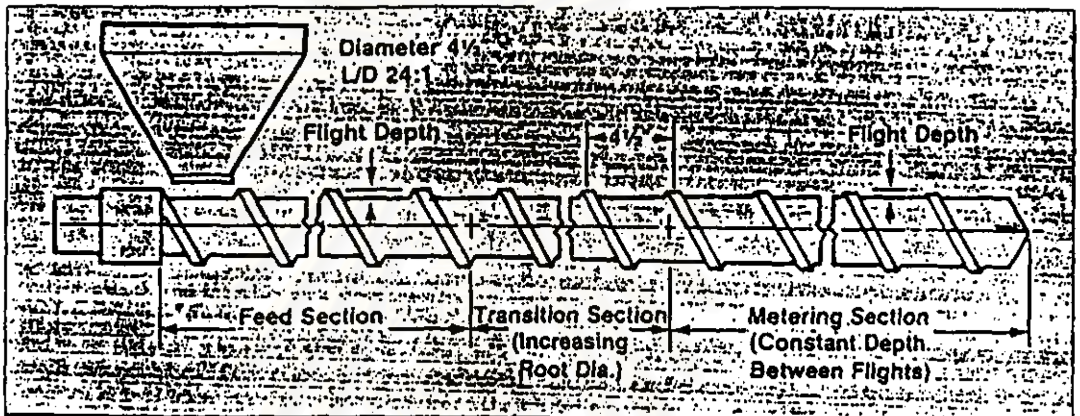
1.1.1.2 Journey to the front of the extruder The plastic pellets inside the extruder barrel are conveyed toward the die at the end of the extruder. During conveying, the plastic pellets are melted due to friction heat caused by the shear action of the screw and the barrel. About 50% of the pellets are melted at the middle section of screw (Transition section). The plastic pellets are totally melted in the final third of the barrel and screw (Metering section). Actually, approximately 85% to 90% of the energy exerted to single screw extruder are required to melt plastic, while the electric bands on the outside of the barrel serve only as thermal blankets and to facilitate start ups. Figure 4.1 illustrates the typical features of extruder screw design.

1.1.1.3 Take off unit The melted plastic is forced through die to shape the product. After that, the take off unit pulls the extruded product by its processor to control output rate and product dimension.

1.1.1.4 Cooling station For horizontally extruded product, the cooling station is a tank of water. Such water is used for controlling the temperature. This cooling process takes place between the extrusion die and take off unit.

1.1.2 Thermoforming process [Choetkiettikul, 1996]

This process requires extruded plastic sheet as a starting material. The plastic sheet is firstly placed and clamped in a clamp frame. This is to ensure that such plastic sheet is hold securely on all edges in place. This process can bedone manually, robotically (for high-volume production) or continuously. The heating process consequently provides thermal energy through convection and radiation. Such energy is applied for an adequate time to soften the plastic sheet before shaping by mold.



DIMENSIONS		
	Depth	No. Flights
Feed	0.525"	8
Transition		6
Metering	0.150"	10

Figure 4.1 Features of a single-screw extruder. [Choetkiettikul, 1996]

After plastic sheet is softened properly, it is then brought into contact with mold. A pressure and/or vacuum air is applied that draw the softened sheet downward the mold to mirror the configuration of the mold. Later, it is cooled in mold and the mold disengages. Now, the cooled sheet retains the shape of the mold. Additionally, cutting process is to cut and remove such final shaped product from the cooled sheet. Now the remainder is becoming web and can be recycled.

In the old day, thermoforming process is recognized as a one-sided process which means one-sided tolerance determination. Female mold allows the critical outside surface of the product, while male mold allows the critical inside surface of the product as Figure 4.3. It is then used primarily for simple parts. Today, thermoforming process however has been improved and enables manufacturers to produce the product that requires two critical sides and closer dimensional accuracy. Therefore, they can be used in key automotive, building and construction applications.

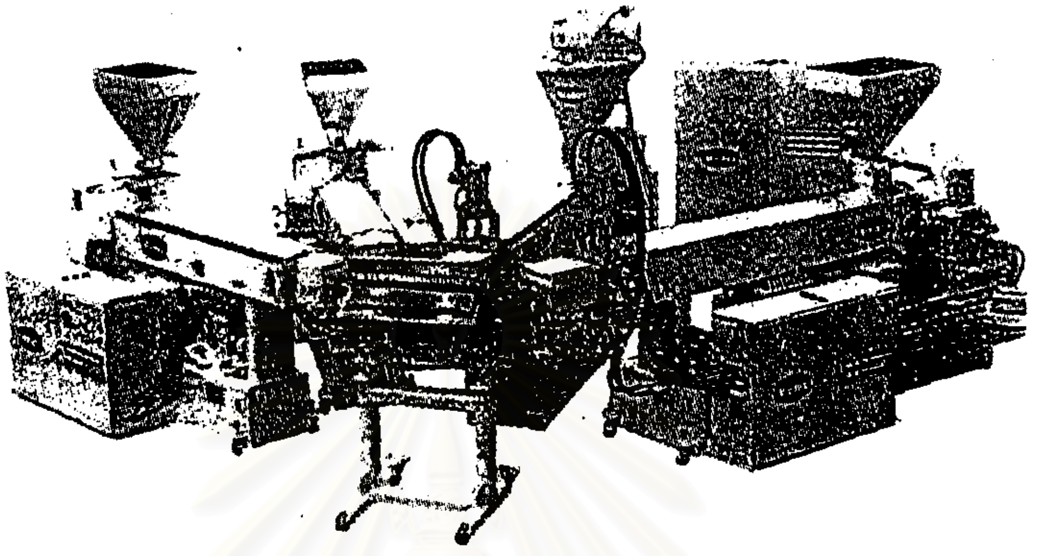


Figure 4.2 Illustration of Co-extrusion line (Courtesy of Welex)

1.1.3 Printing process [Glenn, 1996]

The printing process used for printing cup is dry offset printing. This sort of printing is a two-step process in the way that a soft rubber blanket roll or called "offset cylinder" applies paste ink and image onto the product. This process is considered the superior quality technique and high speed multicolor printing. Such process is an effective process which is capable of printing on irregular surfaces, such as textured web, pouch fin seals, concave can bottoms and so on, or on containers, such as tapered cup, tubs, tubes, jars and beverage cans.

The one color dry offset has a Seri of rollers involving metering roll, doctor blade, plate cylinder, and offset (or print cylinder) as figure 4.5. One to six colors can be printed simultaneously onto the container. Each color requires a separate ink fountain and plate cylinder but all colors print onto the same offset cylinder.

As for its procedures, the ink distributed through such series of rollers. The metering roll firstly rotates and picks up ink from the ink fountain. The images are therefore transferred by mirroring the raised surface of plates on plate cylinder to a rubber blanket on offset cylinder and such blanket then print the entire multi-color image onto the container. It is concisely said that the image is transferred twice in the offset printing process, first onto the offset cylinder and second onto the container as Figure 4.5.

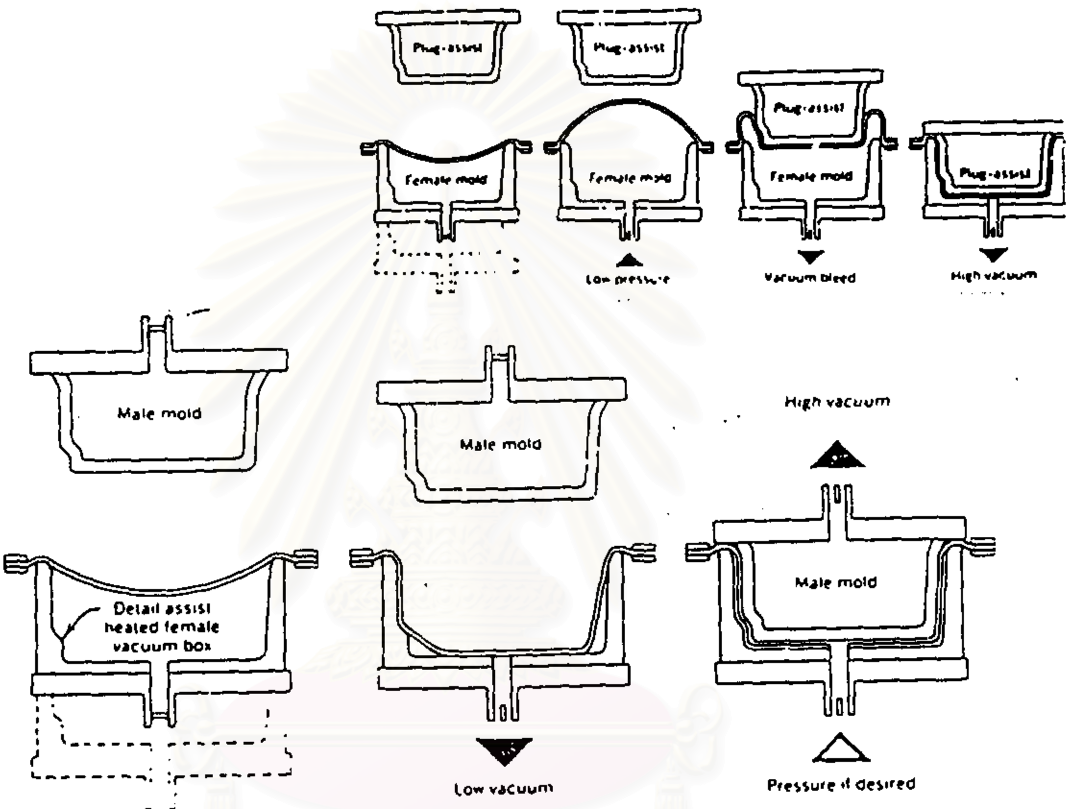


Figure 4.3 Male mould an Female mould of Thermoforming process [Glenn, 1996]

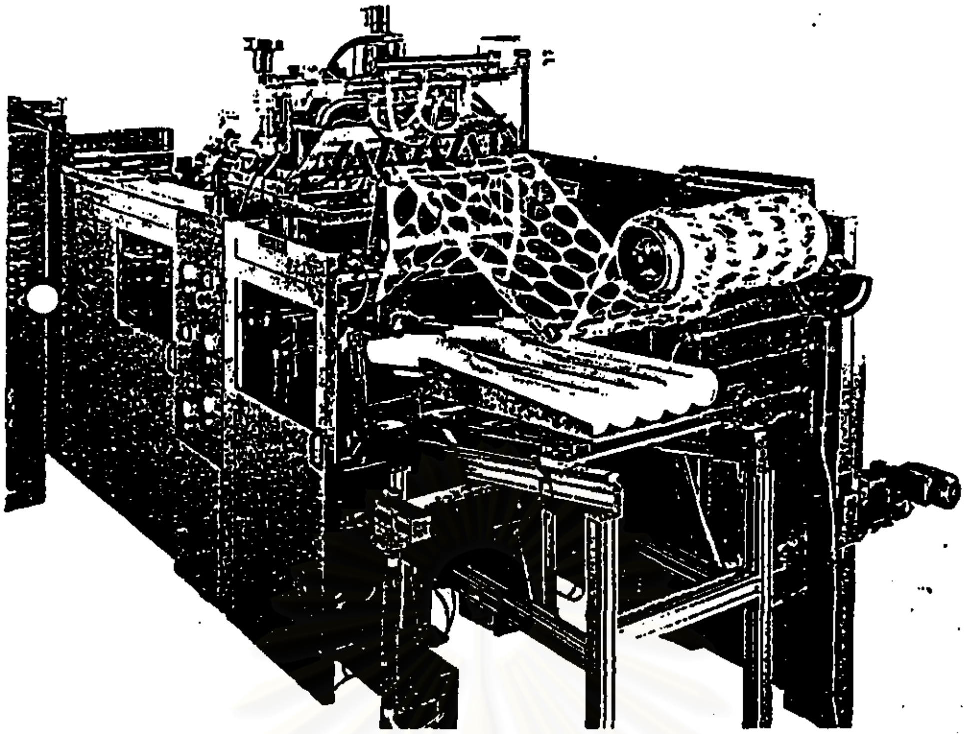
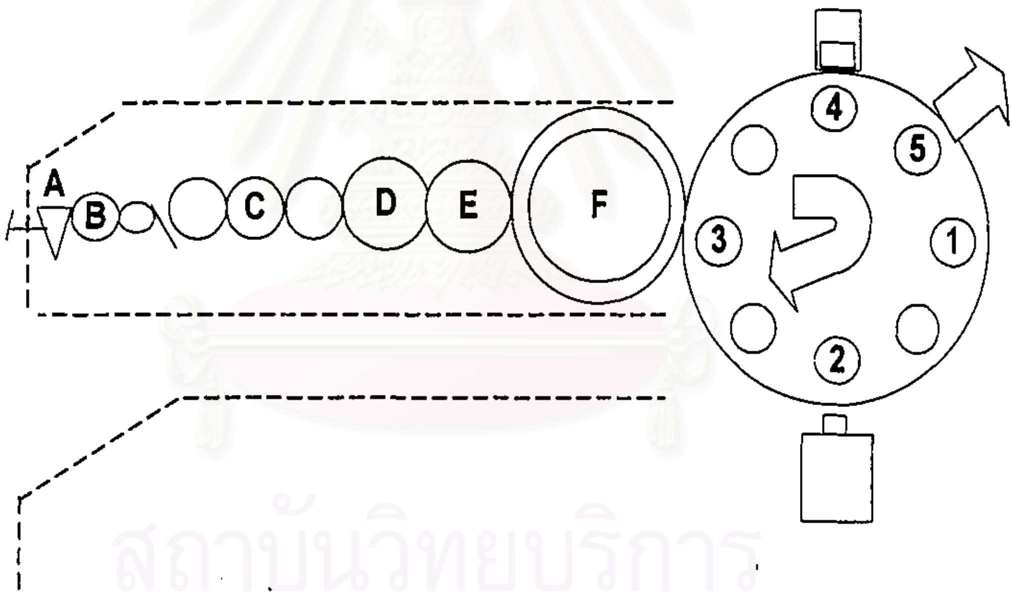


Figure 4.4 Illustration of automatic thermoforming process (Courtesy of Gabler)



Inking station
A: Ink fountain
B: Steel ductor and dab rolls
C: Roller system oscillators and trasfer rolls
D: Form roll
E: Plate cylinder (Printing plate)
F: Blanket platen

1. Feed station
2. Surface treatment (frame or corona)
3. Print station
4. *On mandrel* UV curing (When possible)
5. Transfer to next operation

Figure 4.5 Dry offset printing process [Glenn, 1996]

1.2. Process technical data

1.2.1 Extrusion process [TM, 1996] (Courtesy of David Standard and OMV)

1.2.1.1 Machine maker : David standard

Product specification

* Material : PS, PP
* Width (trimmed) : 600 mm - 800 mm (finished width)
* Thickness range : 0.2 mm - 2 mm. (PS), 0.4 mm - 2 mm (PP)
* Product structure : Co-extrusion : PS
  Layer A/B/C : 15% / 65% / 20%
  Layer A/C/B/C/A : 7.5% / 10% / 65% / 10% / 7.5%
* Output : 400 - 450 Kg / hr (PS)
  300 - 350 Kg / hr (PP)

Equipment specification

* 90 mm., 30/1 : L/D, water cooled extruder with feeder-screw and DC drive system
* 50 mm., 30/1 : L/D air cooled extruder with feed-screw and DC drive system
* Temperature control panel
* Model HSC-35 and HSC-25 Screen changer with common hydraulic power unit.
* Melt pump network with upstream and down stream adaptor pipes (Design for use with 90 mm. Extruder)
* Three entrance co-extrusion feed block, 915 mm wide sheet die, support stand and adaptor pipe for 50 mm. satelline extruders.
* Model EX-X-PLAR I Chain driven, vertical cooling and polishing unit with winder.
* Material blending, granulation, and conveying equipment

1.2.1.2 Machine maker : Centre ETA (OMV)

Product specification

* Material : PS, ABS, PP
* Gross output (PS) : 400 - 450 Kg/h
* Gross output (ABS) : 350 - 400 Kg/h
* Gross output (PP) : 250 - 300 Kg/h
* Sheet thickness (PS) : 0.2 - 2.0 mm.
* Sheet thickness (ABS) : 0.2 - 2.0 mm.
* Sheet thickness (PP) : 0.4 - 2.0 mm.

Equipment specification

* Extruder size : 100 mm.
* L/D ratio : 35 / 1
* Extruder motor : 160 HP
* Max. screw revs : 145
* Max. flat die width : 700 mm.
* Lip opening : 16
* Roll stack diameter : 268 - 350 - 350 mm.
* Max. roll stack width : 800 mm.
* Nip rolls power : 40 Kg/linear cm.
* Extruder heat exchanger : 3 mq
* Roll stack heat exchanger : 3 x 3 mq
* Chiller : 86,000 Cal/h
* Total installed heating power : 236 KW
* Total installed motor power : 204 KW
* Max. compressed air consumption : 4,000 N l/min
* Max. water consumption : 450 l/h

1.2.2 **Thermoforming process** [TM, 1996] (Courtesy of Gabler and OMV)

1.2.2.1 **Machine maker** : **Gabler**

* Machine model : DP450B
* Width of film max./ min. : 450 / 350 mm.

* Forming area max. (Combined forming punching) : 430 / 160 mm.
* Drawing depth max. : 6 / 20 mm.
* Top heater max. : 18.20 KW
* Driving motor : 3.0 KW
* Total connected load at 100% duty cycle : 21.2 KW
* Working air pressure : 6 bar
* Air consumption max. : 1,250 l/min
* Rate of water flow max. : 1.0 cubic m/h
* Length / width / height (without stacking device) approx. : 3000 * 1800 * 2000 mm
* Weight without tool : 1500 Kg

Table 4.1 Product characteristics for DP450B

Product	Tray size II	Tray size III	Tray size IV	Tray size V
Article dimensions	194*114 mm	185*115 mm	188*125 mm	200*115 mm
Gms/pcs.	8.5	8.3	9.0	9.0
Tool arrangement	2 cavities, 1 row, straight placed			
Material	PS			
Film thickness	0.35 mm			
Cycle rates	Approx. 30/min			

1.2.2.2 <u>Machine maker</u> : Gabler

Table 4.2 Product characteristics for F470

Product	Dish size I	Dish size II	Tray size I
Article dimensions	155D, 15H	180D, 20H	188*125 mm
Gms/pcs.	6.3	8.5	9.8
Tool arrangement	4	2	4
Material	PP	PP	PS
Film thickness	0.37 mm	0.36 mm	0.35 mm
Cycle rates	25	25	30

* Machine model : F470

* Drawing depth max. : up to 60 mm.
* Forming area max. : 430 / 290
* Total connected load at 100% duty cycle : 39.0 KW
* Air consumption max. : 6,500 l/min
* Water consumption max. : 45.0 l/min

1.2.2.3 Machine maker : OMV

* Machine model : F30 Thermo-former
* Material : PS, PP, ABS, PVC, PE
* Max. forming area : 540 * 330 mm.
* Min. forming area : 250 * 90 mm.
* Max. sheet width : 600 mm.
* Sheet thickness : 0.25 - 2.0 mm.
* Max. forming depth : 130 mm.
* Min. positive forming : 10 mm.
* Forming with compressed air : 5 - 6 bar.
* Reflector length : 1500 mm.
* Press power : 22 t
* Max. air consumption : 4000 N l/min
* Min. water consumption : 1500 l/h
* Max. vacuum consumption : 180 cubic m/h
* External dimensions : 3200 * 1700 * 2700 mm.
* Weight : 5000 Kg.
* Main drive CC motor 6.9 KW

  Toothed belt transmission

  Worm screw reducer

  10 - 36 rpm on the driven shaft

  Central lubricant system
* Electrical system Total installed power 129 KW

  Total installed heating power 102 KW

  9 upper zones : electronic heat control with thermo-regulators

  8 lower zones : electronic heat control with thermo-regulators

Table 4.3 Product Characteristic for F30

Product	9-oz cup	12-oz cup	16-oz cup	Bowl size I	Bowl size II
Article dimensions	75 D, 95 H	80 D, 110 H	90 D, 125 H	135 D, 55 H	145 D, 68 H
Gms/pcs.	3.0	4.5	7.4	5.8	14.3
Tool arrangement	18	15	15	8	6
Material	PP	PP	PP	PP	PP
Film thickness	0.64, 0.69 mm	0.88, 0.92 mm	1.15 mm	0.59 mm	0.90 mm
Cycle rates	20	20	18	20	20

1.2.3 Printing process [TM, 1996] (Courtesy of VANDAM)

* Machine maker : VANDAM
* Machine model : 565C
* Output rate : 250 cups / min.
* Total connected load : 6 KW
* Air consumption max. : 4500 l/min
* Belt feeder, feed tube, (max. cup dia. 120 mm)
* AC drive motor 120/90° index mechanism, offset cylinder, pneumatic control, operator control panel, PLC control, central lubrication, and vacuum pump for vacuum mandrels.
* 4 color heads 565C
* Screw feeder for cup dia 50 - 133 mm.
* Set of blow-piece in screw feeder.
* Mechanical take-off system (MTO)
* Hold on mechanism
* Gas flame pre treatment system, complete with mandrel unit, gas/air mix cabinet and burner for one cup type.
* Ultra-violet offline conveyor, cooling system/vacuum blower and electrical cabinet

1.3 Capacity and technical analysis [TM, 1996]

1.3.1 DP450B

Table 4.4 Sale forecast per month for DP450B

Product	Yr 1 Million	Yr 2 Million	Yr 3 Million	Yr 4 Million	Yr 5 Million	Yr 6 Million	Yr 7 Million	Yr 8 Million	Yr 9 Million	Yr 10 Million
Tray II	1.646	1.975	2.370	2.844	3.413	4.096	4.915	5.898	7.078	8.493
Tray III	0.412	0.494	0.593	0.711	0.853	1.024	1.229	1.474	1.769	2.123
Tray IV	0.412	0.494	0.593	0.711	0.853	1.024	1.229	1.474	1.769	2.123
Tray V	0.823	0.988	1.185	1.422	1.707	2.048	2.457	2.949	3.539	4.247
Total	3.292	3.950	4.740	5.689	6.826	8.192	9.830	11.796	14.155	16.966

1.3.1.1 Process characteristics

Good yield : 99%

Machine utilization : 95%

Working hours per month : 560 Hrs.

Cycle rate : 30 / min.

Capacity : Based on table 4.1

Product	Tray II	Tray III	Tray IV	Tray V
Expected capacity (Pcs/month)	1,896,048	1,896,048	1,896,048	1,896,048

1.3.1.2 Indicator

Table 4.5 %Share of machine utilization of DP450B

Product	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8
Tray II	86.8%	104.2%	125.0%	150.0%	180.0%	216.0%	259.2%	311.1%
Tray III	21.7%	26.0%	31.3%	37.5%	45.0%	54.0%	64.8%	77.8%
Tray IV	21.7%	26.0%	31.3%	37.5%	45.0%	54.0%	64.8%	77.8%
Tray V	43.4%	52.1%	62.5%	75.0%	90.0%	108.0%	129.6%	155.5%
Total	173.6%	208.3%	250.0%	300.0%	360.0%	432.0%	518.4%	622.1%

1.3.1.3 Conclusion According to table 4.5, it is conservatively thought that two DP450Bs are to yield appropriate capacity in handling the expected demand until the 3rd year of project. Additionally, the reason of using two DP450Bs is illustrated as follows :

- **Maximum drawing depth** According to DP450B's technical data, its maximum drawing depth is approximately up to 20 mm. that is deep enough for the product prospects.
- **Economy** In fact, this machines are available Thailand plant but barely utilized. It is thus recommended to move to China.
- **Width of film** According to DP450B's technical data, allowable film width of 350 - 450mm. can fit the width of extrusion machine.
- **% Utilization of forming area** Such percentage ranging from 60% to 70% is rather acceptable.

1.3.2 F470

Table 4.6 Sale forecast per month for F470

Product	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Tray I	0.823	0.988	1.185	1.422	1.707	2.048	2.457	2.949	3.539	4.247
Dish I	0.686	0.823	0.988	1.185	1.422	1.707	2.048	2.457	2.949	3.539
Dish II	0.686	0.823	0.988	1.185	1.422	1.707	2.048	2.457	2.949	3.539
Total	2.195	2.634	3.160	3.792	4.551	5.461	6.553	7.864	9.437	11.324

1.3.2.1 **Process characteristics**

Good yield : 99%

Machine utilization : 95%

Working hours per month : 560 Hrs.

Cycle rate : 30 / min. (PS) , 25 / min. (PP)

Capacity : Based on table 4.2

Product	Tray I	Dish I	Dish II
Expected capacity (Pcs/month)	3,792,096	1,580,040	3,160,080

1.3.2.2 **Indicator** Table 4.7

1.3.2.3 **Conclusion** With reference to table 4.7, it can be conservatively seen that one F470s can handle the expected demand until the 2nd year of the project. It is therefore concluded that two F470s are to be invested at the beginning of the project. Besides, the technical reason of using F470s are :

Table 4.7 % Share of machine utilization of F470

Product	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8
Tray I	21.7%	26.0%	31.3%	37.5%	45.0%	54.0%	64.8%	77.8%
Dish I	43.4%	52.1%	62.5%	75.0%	90.0%	108.0%	129.6%	155.5%
Dish II	21.7%	26.0%	31.3%	37.5%	45.0%	54.0%	64.8%	77.8%
Total	**86.8%**	**104.2%**	**125.0%**	**150.0%**	**180.0%**	**216.0%**	**259.2%**	**311.1%**

* **Maximum drawing depth** With reference to F470's technical data, it can be seen that maximum drawing depth is up to 60 mm. that meets the requirement.

* **% Utilization of forming area** Ranging from 40% and 60% for circular shape and 75% for rectangular shape, such figures seems to be satisfactory in economic production.

* **Width of film** According to F470's technical data, allowable film width of 350 - 450mm. can fit the width of extrusion machine.

1.3.3 OMV Centre ETA F-30

Table 4.8 Sale forecast per month for Centre ETA F30

Product	Yr 1 Million	Yr 2 Million	Yr 3 Million	Yr 4 Million	Yr 5 Million	Yr 6 Million	Yr 7 Million	Yr 8 Million
9-oz cup	4.115	4.938	5.926	7.111	8.533	10.239	12.287	14.745
12-oz cup	9.876	11.851	14.221	17.066	20.479	24.575	29.490	35.388
16-oz cup	2.469	2.963	3.555	4.266	5.120	6.144	7.372	8.847
Bowl I	1.029	1.235	1.481	1.778	2.133	2.560	3.072	3.686
Bowl II	0.686	0.823	0.988	1.185	1.422	1.707	2.048	2.457
Total	**16.460**	**19.752**	**23.702**	**28.443**	**34.132**	**40.958**	**49.149**	**58.979**

1.3.3.1 Process characteristics

Good yield	:	99%
Machine utilization	:	95%
Working hours per month	:	560 Hrs.
Cycle rate	:	18 - 20 / min.
Capacity	:	Based on table 4.3

Product	9-oz cup	12-oz cup	16-oz cup	Bowl I	Bowl II
Expected capacity (Pcs/month)	11,376,288	9,480,240	8,532,216	5,056,128	3,792,096

1.3.3.2 Conclusion As can be seen from table 4.9, it can be seen that two Centre ETA F-30s are to be investment at the early phase of the project. This machine technically differs from the other two mentioned thermoforming machines in that such machine is in-line process whereas the others are off-line process. Unlike off-line process, Centre ETA F-30 are in-line process that extrusion is coupled with thermoforming process. This is due to several advantages of using in-line process as addressed below. [OMV, 1996]

1.3.3.3 Indicator

Table 4.9 %Share of machine utilization of Centre ETA F30

Product	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8
9-oz cup	36.2%	43.4%	52.1%	62.5%	75.0%	90.0%	108.0%	129.6%
12-oz cup	104.2%	125.0%	150.0%	180.0%	216.0%	259.2%	311.1%	373.3%
16-oz cup	28.9%	34.7%	41.7%	50.0%	60.0%	72.0%	86.4%	103.7%
Bowl I	20.3%	24.4%	29.3%	35.2%	42.2%	50.6%	60.8%	72.9%
Bowl II	18.1%	21.7%	26.0%	31.3%	37.5%	45.0%	54.0%	64.8%
Total	207.7%	249.3%	299.1%	358.9%	430.7%	516.9%	620.2%	744.3%

* **Higher production output** The demand for cups supposes to be economy of scale. And, such process can effectively lower cost of production for such economy production amount. While, the demands for tray and dish are considerably too low to be economy of scale. Off-line process is then more appropriate.

* **Energy saving** As stated previously, both extrusion and thermoforming need thermal energy to reform or restructure plastic resin and/or film into required products. These are two stages of process. For in-line process, plastic film can be fed through thermoforming right after extrusion process. The heat accumulation of plastic film still remains and thermoforming process consequently applies less heat energy into plastic film than off-line process does.

* **Consistency of product quality** In term of product quality, PP technically needs very careful heat treatment. As a result of that, in-line process has better technology to handle so.

* **In-house scrap management** Unlike off-line process, in line process can actually eliminate scrap management problem incurred during processing. This is because most scraps are totally handled in pipe-line system.

1.3.4 Vandam 565C

1.3.4.1 Process characteristics

Good yield	:	99%
Machine utilization	:	95%
Working hours per month	:	560 Hrs.
Operating cycle rate	:	250 cups / min.

Product	9-oz cup	12-oz cup	16-oz cup
Expected capacity (Pcs/month)	7,900,200	7,900,200	7,900,200

Table 4.10 Sale forecast per month for Vandam 565C

Product	Yr 1 Million	Yr 2 Million	Yr 3 Million	Yr 4 Million	Yr 5 Million	Yr 6 Million	Yr 7 Million	Yr 8 Million
9-oz cup with printing	1.646	1.975	2.370	2.844	3.413	4.096	4.915	5.898
12-oz cup with printing	3.292	3.950	4.740	5.689	6.826	8.192	9.830	11.796
16-oz cup with printing	2.469	2.963	3.555	4.266	5.120	6.144	7.372	8.847
Total	7.407	8.888	10.666	12.799	15.359	18.431	22.117	26.541

1.3.4.2 Indicator Table 4.11

1.3.4.3 Conclusion [Rolid ink, 1996] From table 4.11, it is concluded that the expected demand for printing cups need one printing process until the 3rd year of the project. The technical reasons of using Vandam 565C are :

* **Take-off unit** Mechanic Take Off unit (MTO) is strongly recommended because such take-off mechanism has flexibility to handle all product prospects effectively.

* **Feed tube, belt, and screw feeder** Vandam 565C suits the requirement that maximum diameter for such printing machine is 120 mm., while the maximum diameter of cup prospect is just 90 mm.

* **Pre-treatment process** To be able to attain trouble free adhesion on PP product that brings about the difficulties in printing process, pre-treatment process is strongly suggested. In general, pre-treatment process methods are Corona treatment, and Gas frame treatment. Due to the product prospects being quite large containers, Gas frame treatment is therefore suitable process.

* **Heat treatment process** Heat treatment system is to dry printed product before packing. Technically, UV treatment system is worldwide recognized.

Table 4.11 %Share of machine utilization of Vandam 565C

Product	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8
9-oz cup	14.5%	17.4%	20.8%	25.0%	30.0%	36.0%	43.2%	51.8%
12-oz cup	34.7%	41.7%	50.0%	60.0%	72.0%	86.4%	103.7%	124.4%
16-oz cup	28.9%	34.7%	41.7%	50.0%	60.0%	72.0%	86.4%	103.7%
Total	**78.1%**	**93.8%**	**112.5%**	**135.0%**	**162.0%**	**194.4%**	**233.3%**	**280.0%**

1.3.5 Davis standard

1.3.5.1 Process characteristics

Good yield : 99%

Machine utilization : 95%

Working hours per month : 560 Hrs.

% utilization of forming area (AVG.) : 50%

Type of plastic film	**PS**	**PP**
Expected capacity (Kgs/month)	210,672	158,004

Table 4.12 Expected down-stream consumption per month for Davis Standard

Product Kg/month	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8
Tray I	8,065	9,678	11,614	13,937	16,724	20,069	24,083	28,900
Tray II	13,991	16,789	20,147	24,176	29,012	34,814	41,777	50,132
Tray III	3,415	4,099	4,918	5,902	7,082	8,499	10,198	12,238
Tray IV	3,704	4,444	5,333	6,400	7,680	9,216	11,059	13,270
Tray V	7,407	8,888	10,666	12,799	15,359	18,431	22,117	26,541
Dish I	4,321	5,185	6,222	7,466	8,960	10,751	12,902	15,482
Dish II	5,830	6,996	8,395	10,074	12,088	14,506	17,407	20,888
Total	**28,517**	**34,220**	**41,064**	**49,277**	**59,133**	**70,959**	**85,151**	**102,182**

Table 4.13 Plastic film requirement per month of Davis Standard

Film Kg/month	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8
PP	20,301	24,361	29,233	35,080	42,096	50,515	60,618	72,741
PS	58,351	70,021	84,025	100,830	120,996	145,196	174,235	209,082
Total	**78,652**	**94,382**	**113,258**	**135,910**	**163,092**	**195,710**	**234,852**	**281,823**

1.3.5.2 Indicator

Table 4.14 %Share of machine utilization of Davis Standard

Type of film	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8
PP	12.6%	15.4%	18.5%	22.2%	26.6%	32.0%	38.4%	46.0%
PS	36.9%	44.3%	53.2%	63.8%	76.6%	91.9%	110.3%	132.3%
Total	**36.9%**	**44.3%**	**53.2%**	**63.8%**	**76.6%**	**91.9%**	**110.3%**	**132.3%**

1.3.5.3 Conclusion From table 4.14, it can be seen that one off-line extrusion machine supposes to suit the expected demand until the 7th year of project. A couple reasons why using David standard are addressed below :

* **L/D ratio** L/D ration of such extrusion screw is 30/1 and universal design that suits the requirement to manufacture both PP and PS film.

* **Expected capacity** The expected capacity for PP is 300 - 350 Kg/hr, while capacity for PS is 400 - 450 Kg/hr. Such capacity amount seems to be adequate and standard.

* **Film thickness/width** From DAVID STANDARD 's technical data, thickness range is 0.2 to 2.0 mm for PS and 0.4 to 2.0 mm for PP. Such ranges match the product requirement. For width of film, this extrusion process is capable of producing film of 600 to 800 mm. width that fits the thermoforming process's requirement.

1.4 Summary for manufacturing analysis

1.4.1. Investment plan

According to Table 4.5, 4.7, 4.9, 4.11, and 4.14, the summary for ten-year investment plan are concisely presented as Table 4.15.

Table 4.15 Ten-year investment plan for China project

Number of machine line										
Machine type	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**
DP450B	2	2	3	3	4	5	5	6	8	9
F470	1	1	2	2	2	2	3	3	4	5
OMV Center -ETA	2	3	3	4	5	5	6	8	9	11
Vandam 565C	1	1	1	2	2	2	3	3	4	4
Davis standard	1	1	1	1	1	1	1	2	2	2

1.4.2 Expected actual production for the first stage of investment

By considering process capacity, expected production program, investment plan, and total sale forecast for the whole project, expected actual production volume for the first stage of investment that directly reflects how much sale revenue will come up can be figured out as the following equation (4.1).

$$X = MIN(C, A*B) \qquad (4.1)$$

Whereas X = Expected actual production for the first stage of investment

A = Production program

B = Total capacity

C = Total sale forecast of the whole project

1.4.3 Conditions in calculating expected production for the first stage of investment

* First stage of investment : Extrusion process : Davis standard : one machine.
Thermoforming process : DP450B : two machines.
F470 : one machine.
OMV F-30 : two machines.
Printing process : Vandam 656C : one machine

* Expected production program :

Table 4.16 Expected production program for China project.

Phase	Construciton	Pre-operation.	Operation Year 2 to 10
Year	0	1	100%
Production program (%)	0%	70%	

* Process capacity and total sale forecast : As mentioned previously in capacity analysis and market analysis.

As a result of that, expected production volume for the first stage of investment are demonstrated as Table 4.17 below. Such Table 4.17 will be consequently brought to be an input information for financial feasibility program.

Table 4.17 Actual expected production per month

Product	Yr 1 Million	Yr 2 Million	Yr 3 Million	Yr 4 Million	Yr 5 Million	Yr 6 Million	Yr 7 Million	Yr 8 Million
9-oz cup	1.663	2.375	2.375	2.375	2.375	2.375	2.375	2.375
9-oz cup with printing	1.023	1.462	1.462	1.462	1.462	1.462	1.462	1.462
12-oz cup	4.433	6.333	6.333	6.333	6.333	6.333	6.333	6.333
12-oz cup with printing	2.461	3.516	3.516	3.516	3.516	3.516	3.516	3.516
16-oz cup with printing	2.046	2.923	2.923	2.923	2.923	2.923	2.923	2.923
Bowl size I	0.694	0.991	0.991	0.991	0.991	0.991	0.991	0.991
Bowl size II	0.467	0.667	0.667	0.667	0.667	0.667	0.667	0.667
Dish size I	0.553	0.790	0.790	0.790	0.790	0.790	0.790	0.790
Dish size II	0.553	0.790	0.790	0.790	0.790	0.790	0.790	0.790
Tray size I	0.664	0.948	0.948	0.948	0.948	0.948	0.948	0.948
Tray size II	1.327	1.896	1.896	1.896	1.896	1.896	1.896	1.896
Tray size III	0.332	0.474	0.474	0.474	0.474	0.474	0.474	0.474
Tray size IV	0.332	0.474	0.474	0.474	0.474	0.474	0.474	0.474
Tray size V	0.664	0.946	0.948	0.946	0.948	0.948	0.948	0.948
Total	17.21	24.58	24.58	24.58	24.58	24.58	24.58	24.58

2. Organization chart

2.1 Head office

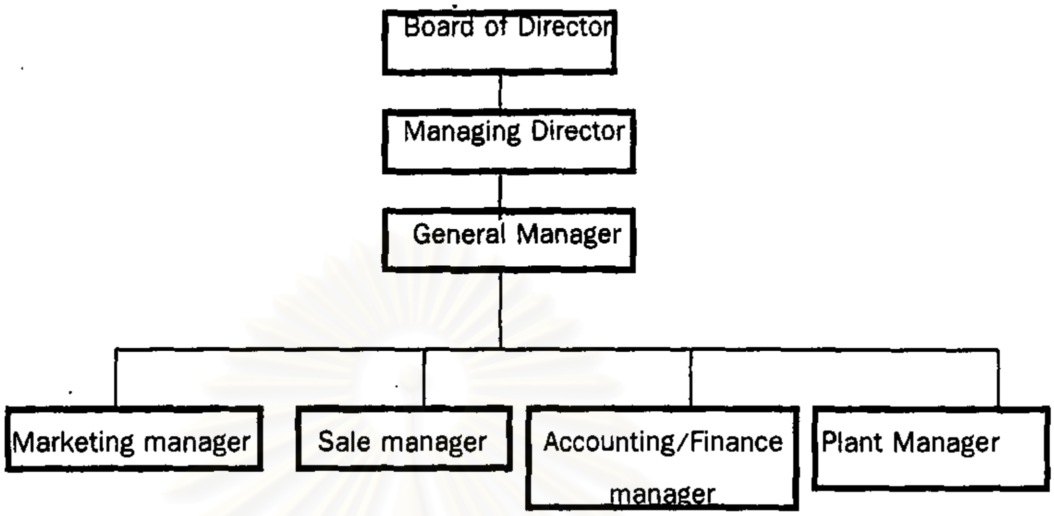


Figure 4.6 An organization chart of management level of the company

2.2 Plant

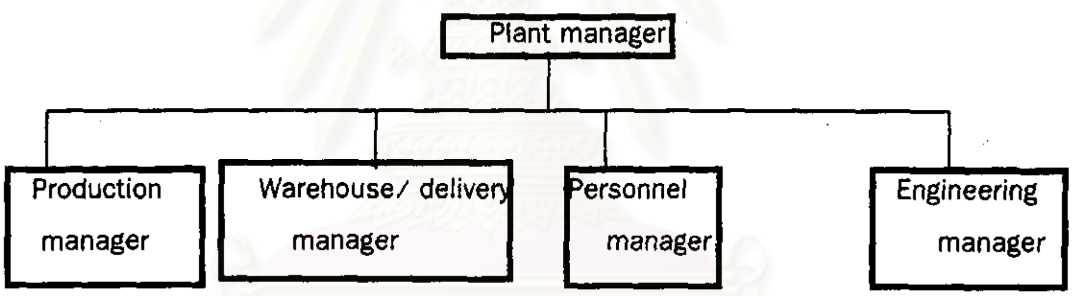


Figure 4.7 An organization chart of operation level of the company

3. **Material technology and Its application** [KLOCK-NER, 1996] [Jenkins, and Harrington, 1991]

In relation to food packaging applications, material selection supposes to be the one of the key for food packaging manufacturing. As discussed previously, three counter balance aspects with respect to material selection are hygienic human need, environmental friendly, and right material / application. In fact, the most commonly used thermoplastic is polypropylene (PP) and polystyrene (PS).

3.1. **Polypropylene** (PP)

Generally speaking, it is expected that PP has tendency to become dominate thermoplastic for food packaging in the world. Technically, PP has the simplest fundamental unit (Propylene monomer) as illustrated below :

$$-\left[CH_2-\underset{\displaystyle CH_3}{\underset{|}{CH}}\right]-$$

The chemical reaction yielding PP is polymerization process. PP structures crystalline nature that provides rigidity and chemical resistance. That also brings about high melting temperature but relatively opaqueness. Until recently, PP grades have been newly developed to enhance better application properties : Optical clarity, scratch resistance, rigidity, and temperature tolerance. The important pros and cons of PP are demonstrated as follows:

3.1.1. **Advantages**

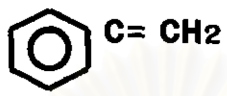
* Water vapor barrier
* Resistance against fat and oily food
* Chemical stability
* Low density
* Environment accepted
* Low material cost

3.2.1 **Disadvantages**

* Difficult to process
* Low temperature impact
* Lack of transparency
* Low gas barrier properties

3.2 Polystyrene (PS)

Polystyrene is widely recognized as the other commonly used thermoplastic in production of food packaging product, disposable medical devices, toys, tumblers. cutlery, tape reels, and also foam products. PS technically structures amorphous nature which do not have crystalline melting temperature but it has broad softening range. It is then advantageous to process. PS has the simplest fundamental unit (Styrene monomer) as below :



Basically, PS can be split into two types as its chemical process. General Purpose Polystyrene (GPPS) is firstly produced by styrene polymerization reaction which yields clear but brittle PS. Whereas High Impact Polystyrene (HIPS) is produced by styrene monomer and polybutadiene, so-called "rubber" that provides better ductility but opaqueness.

By its applications, It is generally said that PS is the appropriate thermoplastic for making food packaging product like PP. It is nonetheless noted that PS is inferior to PP in the fact that PP has narrower application temperature (-10 ^{o}C to 80 ^{o}C) than PP's (-30 ^{o}C to 120 ^{o}C), poor gas/moisture permeability, and furthermore poor resistance to be attacked by oils that is a significant material for Asian food.

4. Plant layout and location [TM, 1996]

Plant location	:	Jiading industry zone, Jianding district (Urban area) 35 KM. Far from Shanghai
Size	:	30 x 86 M.
Rental cost	:	35 $ / Sq. M.
Electricity	:	900 RMB / KVA
Advantages	:	Very convenience in transportation.
Figure 11	:	Plant layout (1st phase of investment)
Figure 12	:	Plant layout (2nd phase of investment)
Figure 13	:	Material and activity flow.

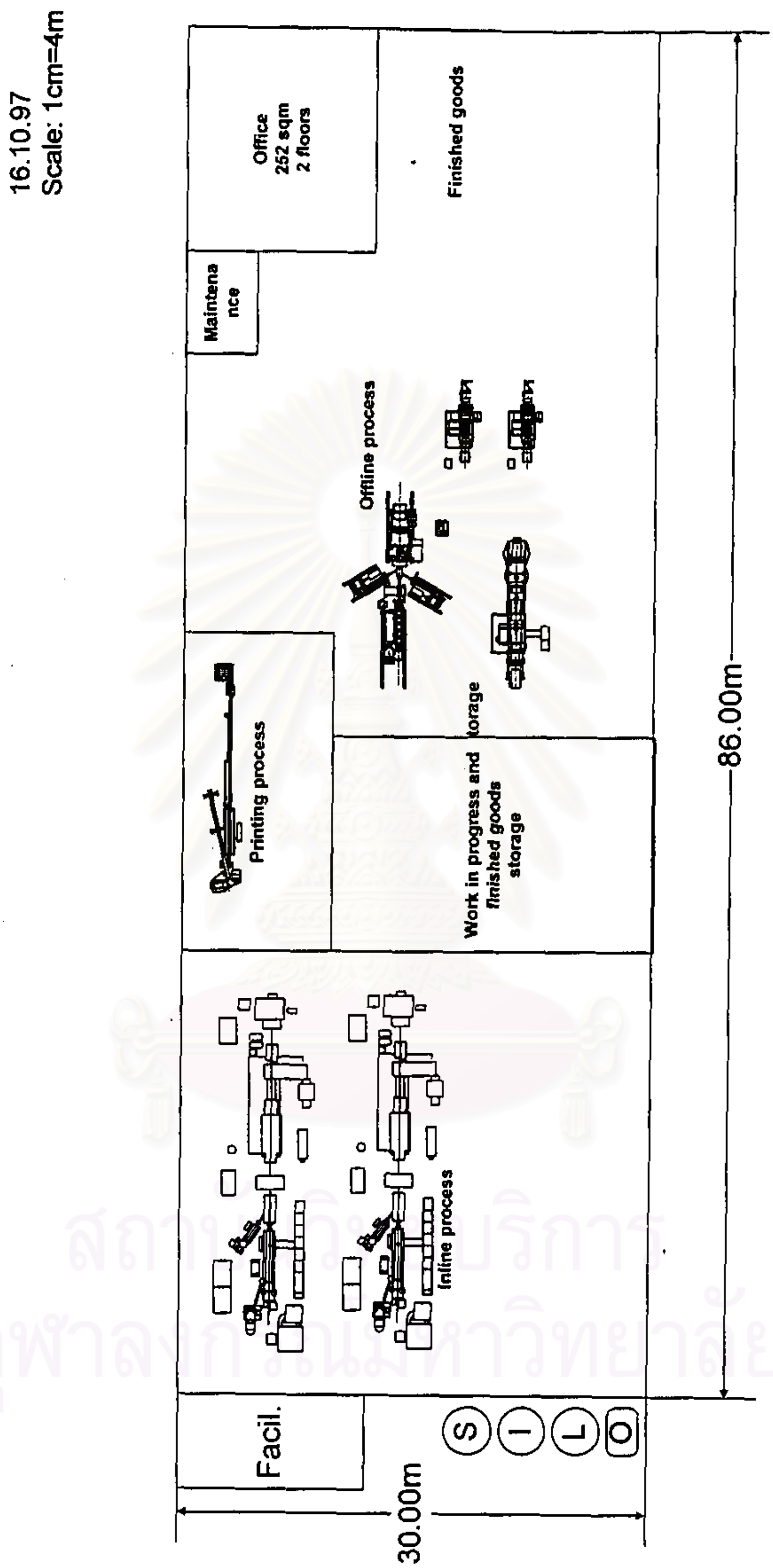


Figure 4.8 Plant layout for 1st phase of investment (Yr 1)

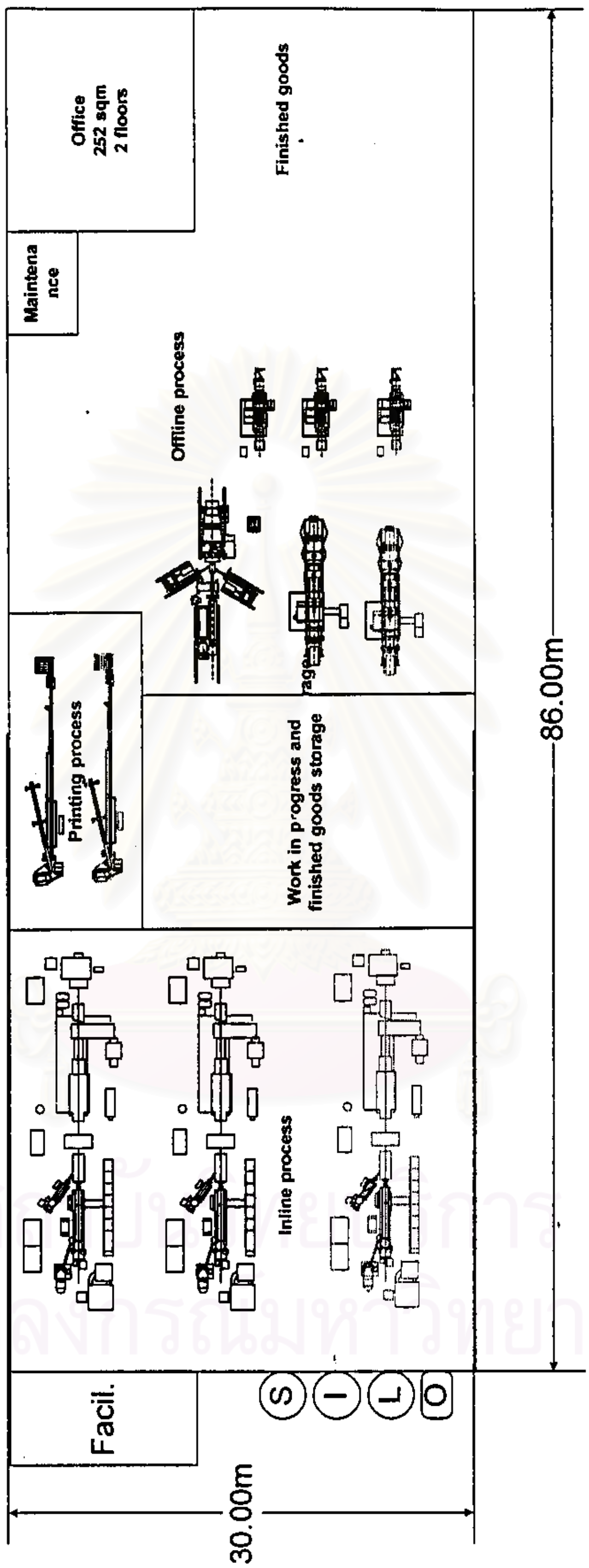


Figure 4.9 Plant layout for 2nd phase of investment (Yr.3)

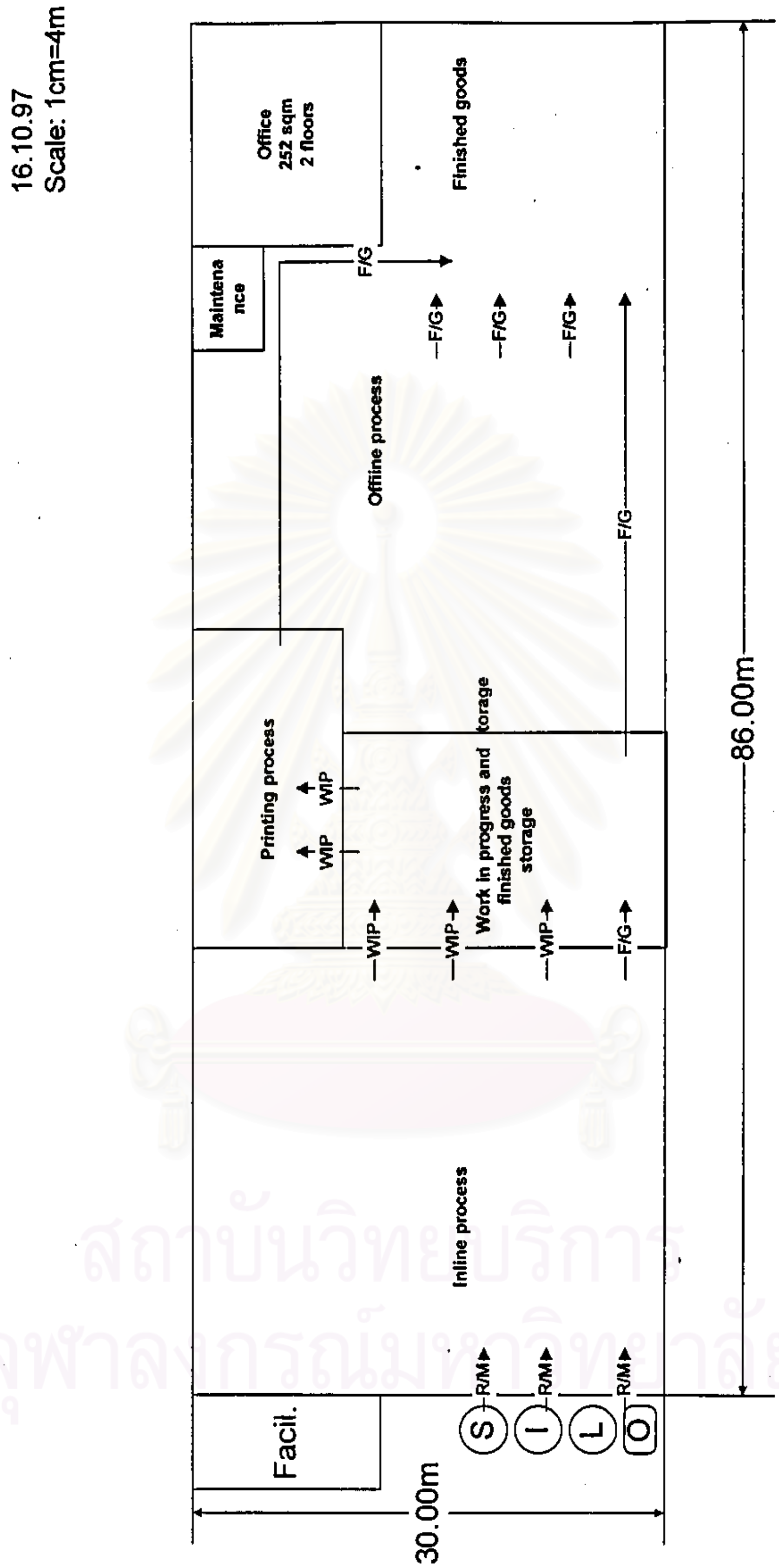


Figure 4.10 Material and activity flow