A FEASIBILITY STUDY OF PURCHASING THE NEW INJECTORS INSTEAD OF HIRING SUB-CONTRACTORS FOR THE PLASTIC INJECTION PLANT

by

Ms. Chanoknun Pattachot

A Final Report of the Three-Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer and Engineering Management
Assumption University

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Project Title	A Feasibility Study of Purchasing the New Injectors Instead of Hiring Sub-contractors for the Plastic Injection Plant
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Academic Year	July 2002

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ABSTRACT

This study examines the feasibility study of purchasing the additional injectors for company's self-injection instead of hiring sub-contractors.

A collection of past sub-contractor orders was conducted to identify the average product amount in order to perceive the additional costs of company's self-injection such as material cost, labor cost, electricity cost, maintenance cost and so on. The evaluation is accomplished via Present-Worth analysis and Incremental analysis. The Present-Worth analysis of purchasing the injectors more than not purchasing equals to 22,322,366 bahts (38,518,492-16,196,126 bahts), conclude that the decision to acquire injectors are very attractive. The result of Incremental analysis is the same as the Present-Worth analysis prior to the not purchasing-to-purchasing comparison, Rate of Return is 34% >4.5% MARR.

Additionally, the sensitivity evaluation was performed to test the decision's correctness and accuracy, which results that the project-acceptance is sensitive to parameter MARR, material cost and overall sales volume. If the MARR is greater than 54.5% or the material cost increase is more than 90% or the overall sales volume reducing is more than 68%, the purchasing-injectors project should be omitted.

ACKNOWLEDGEMENTS

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I. INTRODUCTION

Plastic plays a very important role in our daily life. Because of its unique characteristics: durability, flexibility, lightweight, and relatively inexpensive; plastic is widely used in productions of electronic components, engineering tools, medical equipment, military weapons, sporting goods, building materials, most household products and etc.

1.1 Background of the Project

UC Co., Ltd., a Japanese-Thai joint venture plastic injection & molding company, employs 150 employees and produces 900 different types of plastic products. Its main business is producing electronic components and automotive parts. Today UC Co., Ltd. owns 27 plastic injectors. To meet customers' increasing demand, the company operates 24 hours day. The detailed information on injector capacity (Clamping Ton Force) and their manufactures is shown in Table 1.1.

Table 1.1. The Detail Information on Injectors and Their Manufacturers.

Size of Injector (Ton)	Unit (Injector)	Injector Manufacturer
25 Ton	2	Sumitomo
30 Ton	1	JSW
50 Ton	4	Fanuc
55 Ton	6	Toshiba
75 Ton	2	Sumitomo
80 Ton	2	Sumitomo
80 Ton	1	Mitsubishi
80 Ton	3	Toshiba
100 Ton	3	Fanuc
100 Ton	1	Toshiba
150 Ton	2	Sumitomo

A production process starts with a customer's submission of product specifications: materials, molds, and colors, to UC Co., Ltd. The company then examines the specifications to see whether such product can be made. If the product can be made, the company will produce samples and send them to customer for approval. Once the samples are approved, the company and customer will then negotiate the production cost prior to placing an order.

Before a new product is produced, a technician will examine the dimension (Lx WxH, mm.) of the mold to see which plastic injector is suitable to be used with the particular mold. Most of the time, the molds will be fixed to use with the smallest injector. In some cases where the smallest injector is too busy because of breaking down or running to produce other products, a larger injector will be utilized instead. A good example is the mold model 4PB06934 can take 50 and 55 ton injectors to inject plastic.

Since the beginning of the year 2001, the demand of the products has gradually increased in all injector capacities. The problem occurs when the largest injectors that the company owned are only two 150-ton injectors that are not adequate to meet the customer's needs. The company had to hire a sub-contractor to do additional jobs, which eventually resulted in a higher cost and the complex quality control. Table 1.2 and Table 1.3 show an increasing trend of customer orders that must take 150-ton injector in production and subcontractor outsourcing during January to September 2001, respectively.

Table 1.2. An Increasing Trend of Customer Order Which Taking 150-ton Injector in Production during January to September 2001.

Product Code	Customer Order (*1,000 nieces)								
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
317R-8-0-564-01	100	110	120	120	140	140	140	135	145
HK01-A-C-584-W1	5	5	4	4	6	6	5	5	6
HKOI-A-C-999-09	150	200	250	250	400	400	400	380	380
HKO1-A-C-PF1-09	150	200	250	250	400	400	400	380	380
IIK02-0-C-584-W1	5	5	4	4	6	6	8	8	8
I1K02-0-C-999-09	150	200	250	250	280	280	300	300	300
liK02-0-C-PF1-09	150	200	250	250	280	280	300	300	300
NK02-0-0-D07-02	3	2.5	3	3	3	3	2	2	2
NK06-0-0-171-01	140	140	160	150	200	200	180	150	200
NKO6-0-0-999-01	140	140	160	150	200	200	180	150	200
SS10-0-0-080-1,1	10	9	12	11	13	15	13	13	13
SS10-0-C-080-02	10	10	12	12	13	15	13	13	13
SS10-0-C-080-L1	5	5	5	8	8	8	8	8	8
SS22-B-0-PS0-02	12	13	13	14.5	15	15	12	12	15
SS22-C-0-PSO-02	1	1	1	1	1.2	1.2	1	1	1.5
SS22-D-0-PS0-02	1	1	0.8	1	1.2	1.2	1	1.5	1.5
SS30-1-0-PS0-02	10	10	11	10	12	13	10	10	12
SS30-2-0-PS0-02	1	1	0.9	0.8	1	1	1	1	1.3
TT09-0-0-561-01	7	7.5	7.5	8.0	8	8	8	5.5	7
Total	1,050	1,260	1,514	1,497	1,987	1,992	1,982	1,875	1,993

Table 1.3. An Increasing Trend of Sub-contractor Outsourcing during January to September 2001.

Product Code	Sub-contractor Order (*1,000 pieces)								
	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
317R-8-0-564-01	-	-	120	120	140	140	140	135	145
HK01-A-C-999-09	150	200	250	250	400	400	400	380	380
HK01-A-C-PF1-09	150	200	250	250	400	400	400	380	380
NKO6-0-0-171-01	140	140	160	150	200	200	180	150	200
NK06-0-0-999-01	140	140	160	150	200	200	180	150	200
SS30-1-0-PS0-02	-	10	-	-			-	10	12
SS30-2-0-PS0-02	-	1	-		-	-	-	-	1.3
TT09-0-0-561-01	7	7.5	7.5	8	8	8	8	5.5	7
Total	587	699	948	928	1,348	1,348	1,308	1,211	1,325

So the management has an idea to purchase additional 150-ton injectors in order to satisfy all customer orders instead of hiring subcontractor.

1.2 Objectives of the Project

To study UC Company's financial capabilities prior to purchasing additional 150-ton injectors to maximin the production capacity rather than hiring a sub-contractor to do the job,

1.3 Scope of the Project

This study will be focusing on 2 alternatives. The first alternative is to purchase the same brand and model as the existing injectors. The second alternative is to hire sub-contractors to handle additional workloads.

IL LITERATURE REVIEW

2.1 Injector Structure

Injector generally consists of 3 major parts: Injection Unit, Clamping Unit and Base, as presented in Figure 2.1. Each part of the injector has a specification of functions and many components that will be discussed below.

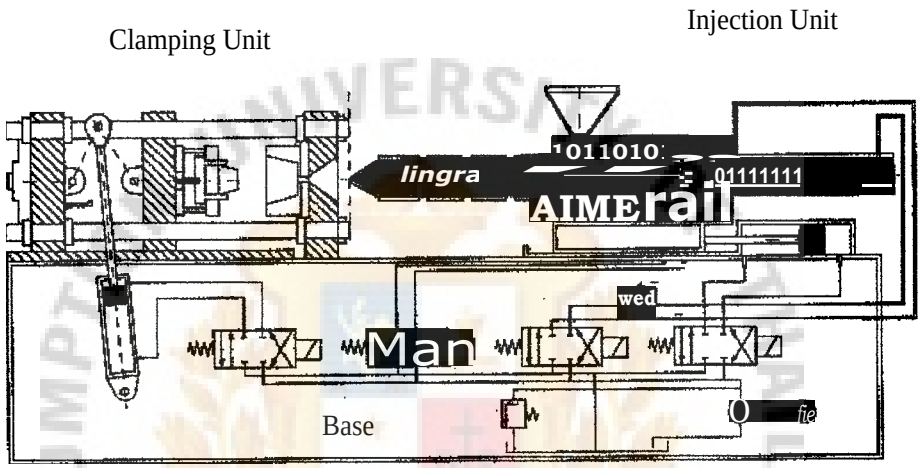


Figure 2.1. Injector Structure.

2.1.1 Injection Unit

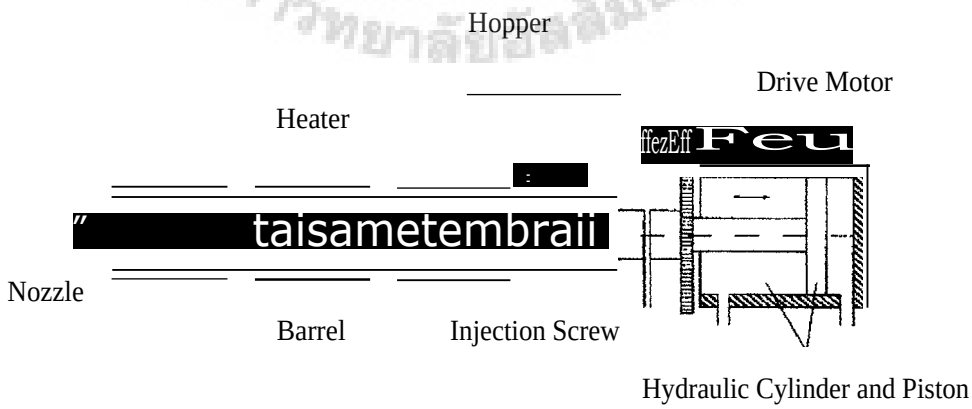


Figure 2.2. Injection Unit.

Injection unit comprises of nozzle, injection screw, barrel, hydraulic-cylinder and piston, heater, hopper and drive motor. Figure 2.2 illustrates the injection unit. The injection unit has following functions:

(a) To feed plastic material into the barrel. The plastic material, which is contained in the hopper, will be fed into the barrel by self-rotation of the injection screw.

(b) To melt and push the plastic material. Fed plastic material will be molten by the heater concurrently transported into the end of injection screw.

(c) To inject and hold pressure. The injection screw will move in horizontal-axis with high speed in order to compress the molten plastic materials, that are in front of the end of injection screw, into the mold. Molten plastic materials will run to the empty areas of the mold until such mold has no spaces, the injection screw will hold with appropriate pressure for tightness of plastic material in the mold.

2.1.2 Clamping Unit

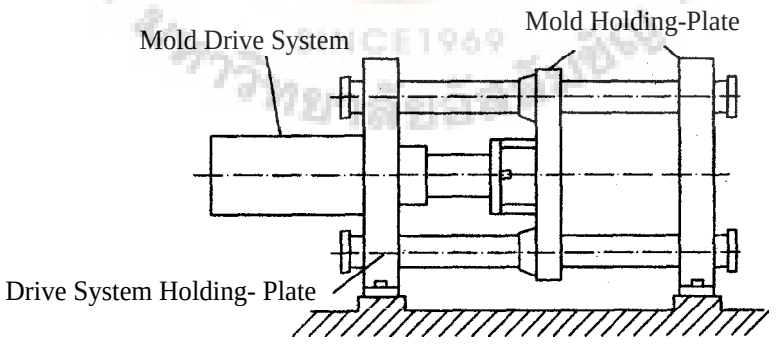


Figure 2.3. Clamping Unit.

The clamping unit is as shown in Figure 2.3. It's functions are as follows:

(a) To hold both movable and fixed components of the mold.

(b) To open and close the mold.

(c) To force close and lock the mold.

(d) To cool the outputs of the injection.

(e) To eject the outputs of the injection.

2.1.3 Base

Base is often made by welding and assembling the tough-steel because it must support the total weight of injection unit and clamping unit, attached to the hydraulic-equipment and hydraulic-oil container.

2.2 Plastic Injection Process

Plastic injection process can be separated into 3 sub-processes: Material preparing, machine setting-up and gate cutting. Some sub-processes are concurrently operated. The details are discussed here:

2.2.1 Material Preparing

Plastic Materials such as POM, PVC, PS, PE, Nylon and ABS, and pigment; are substances that are used to make the various colors of products, that are the main materials of injection process. Both plastic material and pigments will be mixed together for homogeneity by the mixer about 10 minutes and then taken into the dryer to get rid of the humidity by about 8 hours.

In some cases mixing activity will be neglected because the pigments had been mixed together with the plastic material during manufacturing process of plastic materials from the suppliers and these plastic materials are often known as "Color pellets".

2.2.2 Machine Setting-up

The machine setting-up comprises of 3 activities: mold changing, machine cleaning and machine condition adjusting.

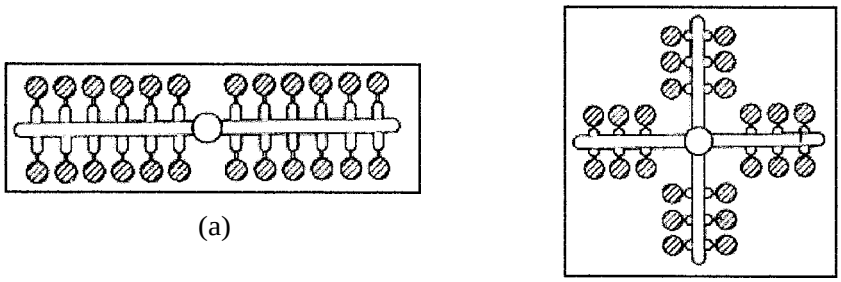
Mold changing is removal of a just completely injected mold with a next-sequence-injecting mold. The components of injectors that must be cleaned are hopper and barrel. Blowing the hopper with the blower and repeatedly wiping off by clothes. For the barrel, injecting natural color of PE until assured that all raw material of preceding product is wiped out. If the preceding product uses the natural color of PE to be raw material, the cleaning-barrel will be omitted.

Machine condition adjusting is a very significant factor that affects the quality of goods: appearances and dimensions. The examples of machine conditions are material melt temperature, mold temperature, injection time and pressure time, cooling time, injection pressure, injection speed, screw rotational speed and screw back pressure

Mold changing step and machine condition adjusting step can simultaneously operate to shorten machine set-up time.

2.2.3 Gate Cutting

The output from 1 machine-running cycle is called "shot". A shot consists of the cavities and the runners, are shown as Figure 2.4. Note that the upward diagonal pattern refers to cavities and white color pattern refers to runners. The amount of cavities equals the number of products. The runner is the path which molten plastic material will flow through into each cavity. A process of splitting the products from the runners known as "Gate Cutting Process."



(a) (b)

Figure 2.4. A Shot Consists of the Cavities and the Runners.

Considering the gate-cutting process to be the criteria, there are 2 groups of products. The first group is the useful-purpose products that are not interested in the good-appearance, consequently the gate-cutting process can be automatically operated by the machine robot. The other group, which emphasizes in shine surface and good-appearance of products, only manpower has responsibility to do the gate-cutting job.

2.3 Mold-Qualification Terminology

Each mold has an identical qualification in production:

(1) Cycle time: The total time that starts with the injector feeds up and melts the plastic material, injects molten plastic to the mold, cools the mold and lastly ejects the output. Unit: seconds

(2) Cavity: The amount of products that will receive from 1 machine-running cycle. Unit: piece

(3) Shot: The output from 1 machine-running cycle that will consist of the products and the runners. Unit: shot

(4) Net-Weight: The total weight of one cavity. Unit: gram

(5) Gross-Weight: The total weight of one shot. Unit: gram

2.4 Economic Engineering

There are four basic methods used to perform an economic analysis: present-worth (PW), equivalent uniform annual worth (EUAW), rate of return (ROR) and benefit/cost ratio. All four methods will give identical decision for alternative selection when applied to the same set of cost and revenue estimates and when the comparisons are properly conducted.

2.4.1 Present-Worth Evaluation

The present-worth (PW) method of alternative evaluation is very popular because future expenditures or receipts are transformed into equivalent dollars now. That is, all the future cash flows associated with an alternative are converted into present dollars. In this form, it is very easy, even for a person unfamiliar with economic analysis, to see the economic advantage of one alternative over or more other alternatives.

2.4.2 Annual-Worth Evaluation

The EUAW (equivalent uniform annual worth) is another method that is commonly used for comparing alternatives. The EUAW means that all incomes and disbursements (irregular and uniform) must be converted into an equivalent uniform annual amount, which is the same each period. The major advantage of this method over all the other methods is that it does not require making the comparison over the least common multiple of years when the alternatives have different lives.

2.4.3 Rate Of Return Evaluation

Rate of return (ROR) is the rate of interest paid on the unpaid balance of borrowed money or the rate of interest earned on the unrecovered balance of an investment (loan) so that the fmal payment or receipt brings balance to zero with interest considered.

2.4.4 Benefit/Cost Ratio Evaluation

The B/C method of analysis is based on the ratio of the benefits to costs associated with a particular project. A project is considered to be attractive when the benefits derived from its implementation, as reduced by expected disbenefits, exceed its associated costs.

III. PROBLEM DEFINITION

3.1 Historical Customer Orders

Although the company has been established for 7 years, the increasing customer orders that caused to hire sub-contractors to do additional jobs occur in the beginning of the year 2001. So it is necessary to concentrate on only the quantity of sub-contractor outsourcing orders during January to September 2001, that are as shown in the table and the bar graph below.

Table 3.1. Sub-contractor Outsourcing Amounts during January to September 2001.

Product Code	Sub-contractor Outsourcing Armunt (piece)					
	Jan-01	Feb-01	Mar-01	Arr-01	may-01	Jun-01
31788-0-564-01	-	-	120,000	120,000	140,000	140,000
1-lK01-A-G999-09	150,000	200,000	250,000	250,000	400,000	400,000
1-11(01-A-C-PF1-09	150,000	200,000	250,000	250,000	400,000	400,000
NK06-0-0-171-01	140,000	140,000	160,000	150,000	200,000	200,000
NK06-0-0-999-01	140,000	140,000	160,000	150,000	200,000	200,000
SS30-1-0-PS0-02	-	10,000	-	-	-	-
SS30-2-0-PS0-02	-	1,000	-	-	-	-
T1 0-0-561-01	7,000	7,500	7,500	8,000	8,000	8,000
Total	587,000	698,500	947,500	928,000	1,348,000	1,348,000

Product Code	Sub-contactor Outsourcin			Atmurt (piece)	
	Jul-01	Aug-01	Sep-01	Total	Average
31788-0-564-01	140,000	135,000	145,000	940,000	104,444
BK01-A-C-999-09	400,000	380,000	380,000	2,810,000	312,222
HK01-A-C-PF1-09	400,000	380,000	380,000	2,810,000	312,222
NK06-0-0-171-01	180,000	150,000	200,000	1,520,000	168,889
NKO6-0-0-999-01	180,000	150,000	200,000	1,520,000	168, N9
SS30-1-0-PS0-02	-	10,000	12,000	32,000	3,556
SS30-2-0-PS0-02	-	-	1,300	2,300	256
TI 0-561-01	8,000	5,500	7,000	66,500	7,389
Total	1,308,000	1,210,500	1,325,300	9,700,800	1,077,867

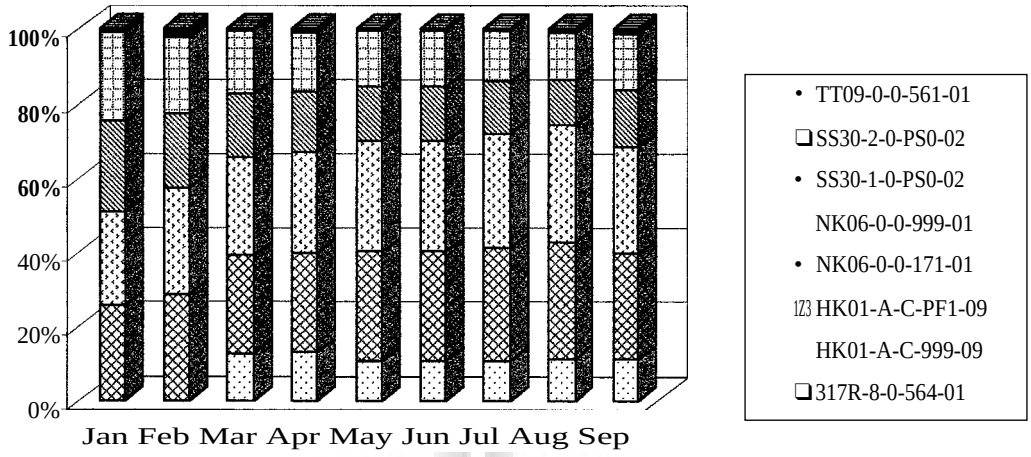


Figure 3.1. Monthly Amount of Sub-contractor Orders
from January to September 2001.

Table 3.1 indicates that the average amount of monthly sub-contractor orders during the past 9 months for the product code 317R-8-0-564-01, I-IK01-A-C-999-09, HK01-A-C-PF1-09, NK06-0-0-171-01, NK06-0-0-999-01, SS30-1-0-PS0-02, SS30-2-0-PS0-02 and TT09-0-0-561-01 is 104,444 pieces, 312,222 pieces, 312,222 pieces, 168,889 pieces, 168,889 pieces, 3,556 pieces, 256 pieces and 7,389 pieces, respectively. The data can be again summarized in the pie graph below.

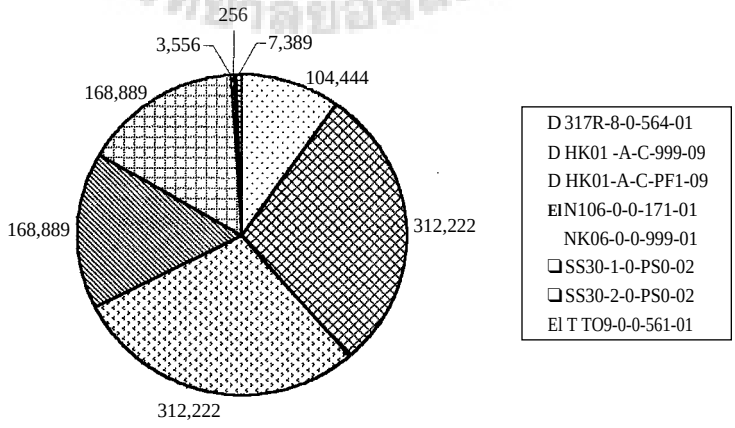


Figure 3.2. Average Amount of Monthly Sub-contractor Orders.

These average amounts of sub-contractor orders will be relied upon in sales and cost estimation throughout the analysis of a purchasing-injectors project. The details of calculation will be gradually described further.

3.2 Injector Capacity

Before analyzing the worth of purchasing the new injector we must know how much exact capacity of the additional injector is acquired in order to satisfy all customer orders without hiring sub-contractors. To recognize the required injector capacity, we can easily translate the sub-contractor orders coupled with the production information that is as presented in Table 3.2 and the results of translation are tabulated in Table 3.3. For the equation to determine the required injector capacity, or injector running time, it may be generalized as follows:

Injector Running Time (second) = Cycle Time * Amount of Orders/ Cavity

Table 3.2. Production Information of Each Product Type.

Product Code	Cavity (piece)	Cycle Time (second)
317R-8-0-564-01	8	26.35
HK01-A-C-999-09	16	28
111(01-A-C-PF1-09	16	38
NK06-0-0-171-01	4	40.8
NK06-0-0-999-01	4	29.4
SS30-1-0-PS0-02	2	22
SS30-2-0-PS0-02	2	22
TT09-0-0-561-01	2	25

Table 3.3. Translation from the Monthly-Amount of Sub-contractor Orders to Required Injector Capacity during January to September 2001.

Product Code	Required Injector Capacity (hours)					
	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01
317R-8-0-564-01		-	110	110	128	128
HK01-A-C-999-09	73	97	122	122	194	194
HK01-A-C-PF1-09	99	132	165	165	264	264
NK06-0-0-171-01	397	397	453	425	567	567
NK06-0-0-999-01	286	286	327	306	408	408
SS30-1-0-PS0-02	-	31	-	-	-	-
SS30-2-0-PS0-02	-	3	-	-	-	-
TT09-0-0-561-01	24	26	26	28	28	28
Total	879	971	1,202	1,155	1,589	1,589

Product Code	Required Injector Capacity (Hours)				
	Jul-01	Aug-01	Sep-01	Total	Average
317R-8-0-564-01	128	124	133	860	96
HK01-A-C-999-09	194	185	185	1,400	156
HK01-A-C-PF1-09	264	251	251	1,900	211
NK06-0-0-171-01	510	425	567	4,307	479
NK06-0-0-999-01	368	306	408	3,103	345
SS30-1-0-PS0-02	-	31	37	98	11
SS30-2-0-PS0-02	-	-	4	7	1
TT09-0-0-561-01	28	19	24	231	26
Total	1,492	1,340	1,608	11,906	1,323

The company policy announces that there are 15 holidays per year, so the average annual workdays equals to 350 days and the annual expected injector capacity should be 8,400 hours due to injector running 24 hours day. Table 3.3 shows that the average required injector capacity to produce all sub-contractor orders is 1,323 hours per month or 15,876 hours per year. So, only one injector is not adequate and eventually two 150-ton injectors are acquired. Because two injectors have the expected injector capacity equals to 8,400*2 = 16,800 hours per year.

Actually, the annual expected injector capacity includes the injector running time and the injector setting-up time. The injector setup activities consist of mold changing, injector cleaning and injector-condition adjusting that all of these activities

approximately take 1 hour per time. The number of monthly injector setup activity is 8 times, because of 8 products type injection per month, or 96 times per year. From this reason the total injector setup time per year is approximately 96 hours, that result in the expected injector capacity of two 150-ton injectors equal to 16,704 hours and as shown in Figure 3.3.

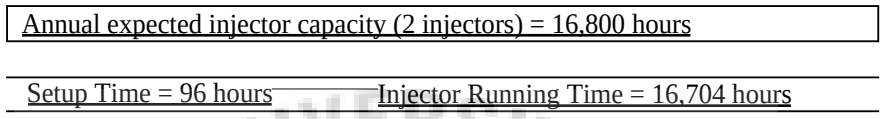


Figure 3.3. Relation of Expected Injector Capacity and Injector Running Time.

Additionally, the expected injector capacity of two injectors that exceeds the required capacity will be able to support the maintenance activities and other uncontrollable events.

3.3 Cost Saving of Company's Self-injection

The procedure of company's hiring sub-contractors starts with the company's defined product specification such as tolerance dimensions, materials, molds and colors to several sub-contractors. After that such sub-contractors will send bids back to the company then the management will select the optimum one and negotiate the contacts.

The price of sub-contractors' proposal will conclude plastic materials, pigments and delivery costs (from Sub-contractor Company to UC Company). Historical data represents that all-8 product types which company hires sub-contractors to do use color pellets as raw materials. Therefore, in order to determine the cost saving of company's self-injection, we only know the quantity of plastic material that can be calculated via the relations:

Quantity of Plastic Material = (Gross Weight * Amount) / Cavity

In Table 3.4, the qualification of each product type, indicated information needed for calculating the quantity of plastic material.

For example, If we acquire 1,000 pieces of product code 317-8-0-564-01, we must use plastic material = (51.51*1,000)/8 = 6,438.75 gram or 6.44 kilogram.

Table 3.4. The Qualification of Each Product Type.

Product Code	Plastic Material	Gross Weight (gram)	Net Weight (gram)	Cavity (piece)
317R-8-0-564-01	PP-AW564	51.51	3.9	8
HK01-A-C-999-09	POM-F2003 (E9000)	102.94	5.37	16
HK01-A-C-PF1-09	POM-F2003 (E9000)	102.94	5.37	16
NK06-0-0-171-01	PP-AH561	111	22	4
NK06-0-0-999-01	PP-AH561	111.53	21.86	4
SS30-1-0-PS0-02	PS-6075	112.56	53.33	2
SS30-2-0-PS0-02	PS-6075	114.02	54.06	2
TT09-0-0-561-01	ABS-KU621	71.17	29.74	2

Normally, the output of 1 cycle machine running consists of 2 major components: the product and the runner. Although the runners can be recycled but mechanical, electrical and thermal property will be few dropped that causes poor quality of our products. So the company policy announces to use only virgin plastic material and these runners will be sold to other companies. The price of buying virgin plastic material and selling scrap is as shown in the next table.

Table 3.5. Price of Buying Plastic Material and Selling Scrap for Each Material Grade.

Material Grade	Buying Plastic Material (bahts/kg.)	Selling scrap (bahts/kg.)
ABS (KU621)	117	12
POM F2003 (E9000)	51	10
PP(AW564)	37	12
PP (AH561)	37	12
PS (6075)	68	10

The amount of scrap from an injector running cycle can be computed as follows:

The amount of scrap = Gross Weight — (Net weight * Cavity)

The cost saving of company's self-injection shown in Table 3.6 includes plastic material costs, but not including the labor costs and overhead costs. The other costs will be added later in the cash flow.

Table 3.6. Cost Saving of Company's Self-injection per Month.

Product Code	Product Amount		Sub-contractor Outsource Cost (bahts/piece)
	(piece)	(shot)	
317R-8-0-564-01	104,444	13,056	0.47
HK01-A-C-999-09	312,222	19,514	0.80
HK01-A-C-PF1-09	312,222	19,514	0.80
NK06-0-0-171-01	168,889	42,222	2.20
NK06-0-0-999-01	168,889	42,222	2.20
SS30-1-0-PS0-02	3,556	1,778	4.80
SS30-2-0-PS0-02	256	128	4.80
TT09-0-0-561-01	7,389	3,695	5.00

Table 3.6. Cost Saving of Company's Self-injection per Month. (Continued)

Product Code	Total Used Material (Kg)	Total Material Cost (bahts)	7%VAT of Material	Total Scrap (Kg)
317R-8-0-564-01	672.51	24,883	1,742	265.17
BK01-A-C-999-09	2,008.77	102,447	7,171	332.13
HK01-A-C-PF1-09	2,008.77	102,447	7,171	332.13
NK06-0-0-171-01	4,686.75	173,410	12,139	971.13
NK06-0-0-999-01	4,709.13	174,238	12,197	1,017.15
SS30-1-0-PS0-02	200.13	13,609	953	10.49
SS30-2-0-PS0-02	14.59	992	69	0.76
TT09-0-0-561-01	262.97	30,768	2,154	43.19
Total	14,563.64	622,795	43,596	2,972.14

Product Code	Refund Scrap Cost (bahts)	Total Self-injection Cost (bahts)	Total Sub-contractor Cost (bahts)	Cost Saving (bahts)
317R-8-0-564-01	3,182	23,443	49,089	25,646
HK01-A-C-999-09	3,321	106,297	249,778	143,480
HK01-A-C-PF1-09	3,321	106,297	249,778	143,480
NK06-0-0-171-01	11,654	173,895	371,556	197,661
NK06-0-0-999-01	12,206	174,229	371,556	197,327
SS30-1-0-PS0-02	105	14,457	17,069	2,612
SS30-2-0-PS0-02	8	1,054	1,229	174
TT09-0-0-561-01	518	32,403	36,945	4,542
Total	34,315	632,076	1,346,998	714,923

The monthly cost of hiring sub-contractor outsourcing is 1,346,998 bahts and the cost of company's self-injection is 632,076 bahts. The company can save 714,923 bahts per month or 8,579,076 bahts per year. The cost comparison of company's self-injecting and hiring sub-contractor is shown in the following figure.

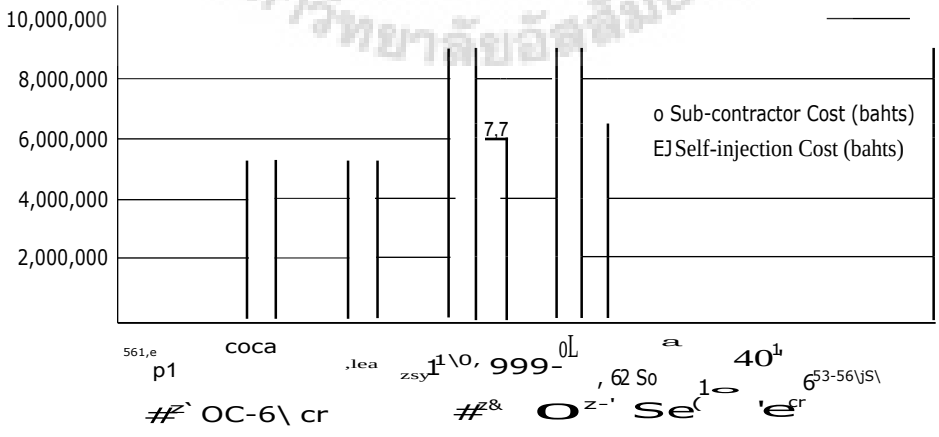


Figure 3.4. Cost Comparison of Self-injecting and Hiring Sub-contractors per Year.

3.4 Investment on Purchasing the Additional 150-Ton Injectors

If the company's management judges to purchase the two additional 150-ton injectors in order to meet all customer orders without hiring sub-contractors, the costs that will incur consist of the initial costs, the operation costs and the maintenance costs. The detail of such costs is discussed here.

3.4.1 Initial Cost

The initial costs that the company must invest can be separated further into 5 items: Injector and equipment, Injector tax, Injector installation cost, Speed dryer and Miscellaneous.

(a) Injector and Equipment

Injector	(8,000,000 bahts/unit) * 2	= 16,000,000 bahts
Hopper	(38,000 bahts/unit) * 2	76,000 bahts
Robot	(450,000 bahts/unit) * 2	900,000 bahts
Heater	(60,000 bahts/unit) * 2	120,000 bahts
Loader	(22,000 bahts/unit) * 2	44,000 bahts

(b) Injector Tax (800,000 bahts/unit) * 2 = 1,600,000 bahts

(c) Injector Installation (30,000 bahts/unit) * 2 60,000 bahts

(d) Speed Dryer (580,000 bahts/unit) * 2 = 1,160,000 bahts

(e) Miscellaneous = 40,000 bahts

Total initial costs = 20,000,000 bahts

3.4.2 Operation Cost

The operation costs, the company will regularly pay, are electricity and labor cost.

(a) Electricity

The existing-lighting system of the plant is sufficient to all areas that causes the company not to improve such system and pay the additional lighting cost when installing the new machines. Consequently the electricity cost of the additional 150-ton injectors can be straightforwardly computed from the machine running time which refers to mixer, dryer and injector.

Since all-8 product types, hiring the sub-contractor to do, use color pellet to be raw material in production process, made the mixers unloaded.

Applying dryer for pre-heat the plastic material takes about 8 hours per time and the monthly pre-heat activity is 8 times, because of needed 8-product types per month. The dryer power is 10 kW.

Therefore,

Electricity (Dryer)

= (8 hours/time)*(8 times)*(10 kW)*(1.7314 bahts/unit)

= 1,108 bahts * 7% VAT

= 1,186 bahts/month or 14,228 bahts/year

The injector power is 30 kW. The injector running times for each product type depend upon the needed product amounts. Table 3.7 tabulates the electricity cost of injectors, which derives from the equation:

Electricity Cost

$$= \frac{[\text{Cycle Time} * \text{Product Amount}]}{\text{Cavity} * 3600} * (30\ \text{kW}) * (1.7314\ \text{bahts/unit})$$

Note that the term in brackets is the calculation of injector running time that is previously represented in Section 3.2.

Table 3.7. Monthly Electricity from Injector.

Product Type	Injector Running Time (Hours)	Electricity Cost (bahts)	7% VAT (bahts)	Total Cost (bahts)
317R-8-0-564-01	96	4,986	349	5,335
11K01-A-C-999-09	152	7,895	553	8,448
HK01-A-C-PF1-09	206	10,700	749	11,449
NK06-0-0-171-01	479	24,880	1,742	26,622
NK06-0-0-999-01	345	17,920	1,254	19,174
SS30-1-0-PS0-02	11	571	40	611
SS30-2-0-PSO-02	1	52	4	56
TT09-0-0-561-01	26	1,350	95	1,445
Total	1,316	68,356	4,785	73,141

Thus, Electricity (Injector) = 73,141 bahts/month or 877,692 bahts/year

(b) Labor Cost

Company employs a worker, 165 bahts/8-workhours. The labor costs seem to occur in 3 cases: the machine setting-up process, the gate cutting process and the quality control process. The machine setting-up process needs only 8 technician-workhours per month. The existing technicians can afford the additional jobs without training the new ones. However such technicians will be able to make productivity in other activities unless they work these setting-up jobs.

So, the labor cost (setting-up process) = 165 bahts per month

= 1,980 bahts per year

The gate cutting process can be categorized further into 2 groups. Product code 317R-8-0-564-01, HK01 -A-C-999-09 and HK01-A-C-PF1-09 are gathered in the first group that the gate cutting process will be automatically operated by an injector-robot without manpower while an injector is running. For this reason the labor cost will not incur in this group.

The second group consists of product codes NK06-0-0-171-01, NK06-0-0-999-01, SS30-1-0-PS0-02, SS30-2-0-PS0-02 and TT09-0-0-561-01. These products emphasizes on the shine-external surface and good-appearance, so the workers must do the gate cutting jobs immediately receiving an output from 1 cycle of injector running in order to protect the scratched products. This implies that the workers must work as long as an injector runs, then the labor cost will be directly computed from the injector running times. Table 3.8 presents the labor costs from gate cutting process.

Table 3.8. Monthly Labor Cost from Gate Cutting Process.

Group	Product Code	Injector Running Time (Hours)	Labor Cost (Bahts)
First	317R-8-0-564-01	96	-
	HK01-A-C-999-09	152	-
	HK01-A-C-PF1-09	206	-
Second	NK06-0-0-171-01	479	9,879
	NK06-0-0-999-01	345	7,116
	SS30-1-0-PS0-02	11	227
	SS30-2-0-PS0-02	1	21
	TT09-0-0-561-01	26	536
		Total	17,779

Usually, for every 4-hour of production, the products will be sampled to test the qualification such as appearances, dimension, tensile strength and so on. The quality control process is a very importance activity because it not only increases the customers' assurance but also follows the ISO 9002 requirements. To supervise and control the quality of products, an additional engineer is needed. The engineer's salary is 20,000 baths per month or 240,000 bahts per year.

Conclusion,

Total Labor Cost = Labor Cost (Set-up process)

+ Labor Cost (Gate-Cut process)

+ Labor Cost (Quality-Control process)

Monthly Labor Cost = 165 + 17,779 + 20,000 = 37,944 bahts or

Annual Labor Cost = 1,980 + 213,348 + 240,000 = 455,328 bahts

3.4.3 Maintenance Cost

(a) Engine Oil (20,000 bahts/injector/year)*2

= 40,000 bahts per year

(b) Preventive maintenance (20,000 bahts/injector/month)*2

= 40,000 bahts per month or 480,000 bahts per year

Thus, Annual maintenance cost = 520,000 bahts.

3.5 Source of Money

The purchasing-injector project requires 20 million bahts in capital. The management has financed project using a Debt-Equity mix of 50% from debt sources and 50% from their own money sources, as illustrated in figure below.

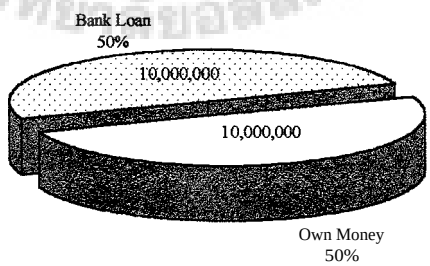


Figure 3.5. Proportion of Equity and Dept Financing.

Debt financing is borrowing via loans costing 7.5% per year compounded monthly. The cost of own money is estimated at 1.5%, which is the opportunity cost of interest from saving account. The Weight Average Cost of Capital (WACC), as shown in Table 3.9, is estimated at 4.50% by using the relation:

WACC = (equity fraction)(cost of equity capital)+(debt fraction)(cost of debt capital)

Table 3.9. Weight Average Cost of Capital.

Source of Money	Amount (bahts)	Proportion	Cost of Capital	WACC
Own Money	10,000,000	50%	1.5%	0.75%
Bank Loan	10,000,000	50%	7.5%	3.75%
Total	20,000,000	100%		4.50%

3.6 Loan Repayment

For financing 10,000,000 bahts from bank at 7.5% per year compounded monthly, the management anticipates to repay within 5 years. The loan repayment is 186,430 bahts per month and 60 months payment period as tabulated in Table 3.10.

Table 3.10. Loan Repayment.

Month	Payment	Interest	Principal	Total owed	Balance
0					10,000,000
1	186,430	37,500	148,930	10,037,500	9,851,070
2	186,430	36,942	149,489	9,888,011	9,701,581
3	186,430	36,381	150,049	9,737,962	9,551,532
4	186,430	35,818	150,612	9,587,350	9,400,920
5	186,430	35,253	151,177	9,436,173	9,249,743
6	186,430	34,687	151,744	9,284,430	9,098,000
7	186,430	34,117	152,313	9,132,117	8,945,687
8	186,430	33,546	152,884	8,979,233	8,792,803
9	186,430	32,973	153,457	8,825,776	8,639,346
10	186,430	32,398	154,033	8,671,743	8,485,313

Table 3.10. Loan Repayment. (Continued)

Month	Payment	Interest	Principal	Total owed	Balance
11	186,430	31,820	154,610	8,517,133	8,330,703
12	186,430	31,240	155,190	8,361,943	8,175,513
13	186,430	30,658	155,772	8,206,171	8,019,741
14	186,430	30,074	156,356	8,049,815	7,863,385
15	186,430	29,488	156,943	7,892,872	7,706,442
16	186,430	28,899	157,531	7,735,341	7,548,911
17	186,430	28,308	158,122	7,577,220	7,390,789
18	186,430	27,715	158,715	7,418,505	7,232,075
19	186,430	27,120	159,310	7,259,195	7,072,765
20	186,430	26,523	159,907	7,099,288	6,912,857
21	186,430	25,923	160,507	6,938,781	6,752,350
22	186,430	25,321	161,109	6,777,672	6,591,241
23	186,430	24,717	161,713	6,615,959	6,429,528
24	186,430	24,111	162,319	6,453,639	6,267,209
25	186,430	23,502	162,928	6,290,711	6,104,281
26	186,430	22,891	163,539	6,127,172	5,940,742
27	186,430	22,278	164,152	5,963,019	5,776,589
28	186,430	21,662	164,768	5,798,251	5,611,821
29	186,430	21,044	165,386	5,632,866	5,446,435
30	186,430	20,424	166,006	5,466,860	5,280,429
31	186,430	19,802	166,629	5,300,231	5,113,801
32	186,430	19,177	167,253	5,132,978	4,946,547
33	186,430	18,550	167,881	4,965,097	4,778,667
34	186,430	17,920	168,510	4,796,587	4,610,157
35	186,430	17,288	169,142	4,627,445	4,441,014
36	186,430	16,654	169,776	4,457,668	4,271,238
37	186,430	16,017	170,413	4,287,255	4,100,825
38	186,430	15,378	171,052	4,116,203	3,929,773
39	186,430	14,737	171,694	3,944,510	3,758,079
40	186,430	14,093	172,337	3,772,172	3,585,742

Table 3.10. Loan Repayment. (Continued)

Month	Payment	Interest	Principal	Total owed	Balance
41	186,430	13,447	172,984	3,599,188	3,412,758
42	186,430	12,798	173,632	3,425,556	3,239,126
43	186,430	12,147	174,283	3,251,273	3,064,842
44	186,430	11,493	174,937	3,076,336	2,889,905
45	186,430	10,837	175,593	2,900,743	2,714,312
46	186,430	10,179	176,252	2,724,491	2,538,061
47	186,430	9,518	176,912	2,547,579	2,361,148
48	186,430	8,854	177,576	2,370,003	2,183,573
49	186,430	8,188	178,242	2,191,761	2,005,331
50	186,430	7,520	178,910	2,012,851	1,826,421
51	186,430	6,849	179,581	1,833,270	1,646,839
52	186,430	6,176	180,255	1,653,015	1,466,585
53	186,430	5,500	180,930	1,472,085	1,285,654
54	186,430	4,821	181,609	1,290,476	1,104,045
55	186,430	4,140	182,290	1,108,186	921,755
56	186,430	3,457	182,974	925,212	738,782
57	186,430	2,770	183,660	741,552	555,122
58	186,430	2,082	184,348	557,204	370,773
59	186,430	1,390	185,040	372,164	185,734
60	186,430	697	185,734	186,430	0

Monthly loan repayment is 186,430 bahts, which consists of interests and principals. By nature the trend of interest payment will be continuously decreasing, otherwise principal repayment will be inherently increasing. If the interest payments and the principal repayments are plotted for series of time, the graph shown in Figure 3.6 is obtained.

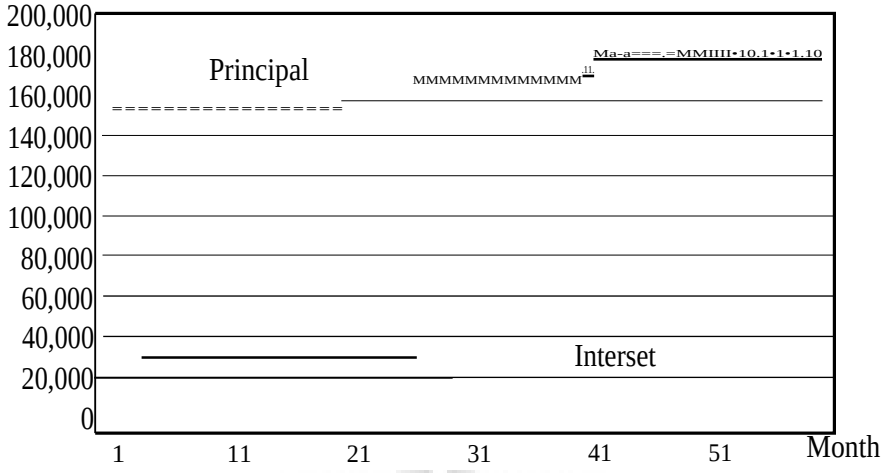


Figure 3.6. The Relation of Interest Payment and Principal Repayment.

To determine the worth of purchasing the 2-injectors we perform an economic analysis in terms of annual revenues and annual costs. Thus monthly interest payment and principal repayment will be accumulated into annual period of time, that are as shown in Table 3.11 and Figure 3.7.

Table 3.11. Annual Interest Payment and Principal Repayment.

Year	Interest	Principal	Total
1	412,675	1,824,487	2,237,162
2	328,858	1,908,304	2,237,162
3	241,191	1,995,971	2,237,162
4	149,497	2,087,666	2,237,162
5	53,590	2,183,573	2,237,162
Total	1,185,812	10,000,000	11,185,812

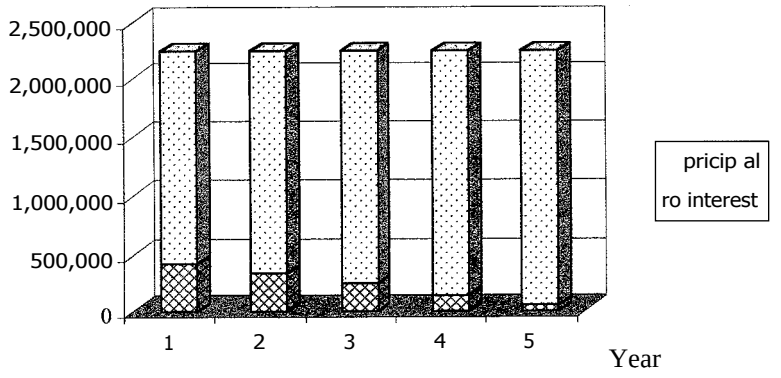


Figure 3.7. Annual Interest Payment and Principal Repayment.

3.7 Depreciation

There are several models approved for depreciating assets, but the Straight-Line (SL) model is the most commonly used. The initial investment has a first cost of 20,000,00 bahts with no salvage value after 10 years. Table 3.12 summarizes the annual depreciation and the book value of the injectors and the equipment after each year, using the Straight-Line depreciation model.

Table 3.12. Depreciation and Book Value.

Year	SL Depreciation	Book Value
0		20,000,000
1	2,000,000	18,000,000
2	2,000,000	16,000,000
3	2,000,000	14,000,000
4	2,000,000	12,000,000
5	2,000,000	10,000,000
6	2,000,000	8,000,000
7	2,000,000	6,000,000
8	2,000,000	4,000,000
9	2,000,000	2,000,000
10	2,000,000	0

IV. PROBLEM SOLUTION

4.1 Income Statement

One of the important financial statements is the income statement, which summarizes the profits or losses of the corporation for a stated period of time. Some terms commonly seen in income statement has the following relation:

Cost of Goods Sold = Material Cost + Labor Cost + Factory Expense

Earning Before Interest and Tax (EBIT) = Net Sale — Cost of Goods Sold

Earning Before Tax (EBT) = EBIT — Interest

Taxable Income (TI) = EBT — Depreciation

Tax = TI * Tax Rate

Net Income =EBT — Tax

4.1.1 Income Statement for Purchasing the Injector

If the two injectors are purchased, the income statement of UC Company is represented in Table 4.1.

For year 1998 to 2000, the annual sales is 6,536,400 bahts, 11,196,000 bahts and 15,809,000 bahts, respectively. And the annual cost of goods sold is 3,653,980 bahts, 6,309,200 bahts and 8,887,650 bahts, respectively. We see that the annual cost of goods sold is usually approximated at 50% of the annual sales. Prior to year 1998 to 2000, the company can meet all customer orders without hiring sub-contractors, causing the engineers to supervise and control the production costs. And this is the reason why the proportion of sales and costs is of constant value.

In the year 2001, more and more customer orders make the company hire the sub-contractors to handle the jobs and consequently the cost of goods sold was increased.

The annual sales is 19,219,628 bahts and the annual cost is 16,163,977 bahts. It shows that the cost of goods sold is up to 84% of the sales.

Income Statement for Purchasing the Injectors.

	Year1998	Year 1999	Year 2000	Year 2001
Net Sale				
Cost			8,887,6501	
Interest				
H			6,921,350	

Net Sale												
Cost												
IInterest			328,8581									
		9,354,793										
IDep.			2,000,000	12,000,000		2,000,000		2,000,0001			2,000,000	
				7,526,276								

Tax (3O%)			2,[illegible]03			163					2,330	
EAT	6,00	7,140		7,[illegible]3	7,[illegible]	7,[illegible]9,715	7,4[illegible]	7,437,[illegible]	7,43[illegible]	7,43[illegible]	7,437,[illegible]	

On the other aspect, the annual sales of year 2001 is more than that of year 2000 equals to 3,410,628 bahts (19,219,628 -15,809,000 bahts), but the Earning After Tax of year 2001 becomes less than that of year 2000 equals to 2,705,989 bahts (4,844,945 — 2,138,956 bahts). This is the significant viewpoint that made the management has an idea to acquire the new injectors in order to increase production capacity.

To fulfill the purchasing-injectors project, the annual sales is forecasted to be constant value of 19,219,628 bahts, which comes from the summary in Table 4.2.

Table 4.2. Annual Net Sales.

Product Code	Product Amount(piece)		Product Price (Baht/piece)	Net Sales (Bahts)
	Monthly	Annually		
317R-8-0-564-01	104,444	1,253,328	0.66	827,196
BK01-A-C-999-09	312,222	3,746,664	1.00	3,746,664
IIK01 -A-C-PF1 -09	312,222	3,746,664	1.00	3,746,664
NK06-0-0-171-01	168,889	2,026,668	2.50	5,066,670
NK06-0-0-999-01	168,889	2,026,668	2.50	5,066,670
SS30-1-0-PS0-02	3,556	42,672	5.10	217,627
SS30-2-0-PS0-02	256	3,072	5.25	16,128
TT09-0-0-561-01	7,389	88,668	6.00	532,008
Total	1,077,867	12,934,404		19,219,628

The annual cost of goods sold equals to 9,452,160 bahts that is the summation of material cost, labor cost, electricity cost and maintenance cost. Using Straight-Line (SL) approach, the annual depreciation is 2,000,000 bahts.

Table 4.1 indicates that throughout project-period, there will be no loss in taxable income and 5-years cumulative of taxable income. So the company will not gain tax saving benefit and necessitate paying tax every year.

4.1.2 Income Statement for Not Purchasing the Injectors

In not purchasing the additional injectors and still hiring the sub-contractor case, the income statement of UC Company is shown in Table 4.3.

Table 4.3. Income Statement for Not Purchasing the Injectors.

	Year 1998	Year 1999	Year 2000	
INet Sale	0	0	0	0
	0	0	0	0
	0	4,886,800	0	0
Interest				
IEBT	0	4,886,800	0	0
	2,882,420	0	0	0

Tax (30%)	0	1,466,040	0	916,695
EAT	2,0	0	4,0	6

	0										
Net Sale	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0
I Interest											
EBT	0	0	0	3,055,651	0	0	0	0	0	0	0
0											
	0	0	0	0	0	0	0	0	0	0	0
5 years cum.	20,801,871	20,975,102	19,143,953	15,278,254	15,278,254	15,278,254	15,278,254	15,278,254	15,278,254	15,278,254	15,278,254

Tax (30%)	916,695	916,695	916,695	916,695	916,695	916,695	916,695	916,695	916,695	916,695	916,695
EAT	2,138,956	2,138,956	2,138,956	2,138,956	2,138,956	2,138,956	2,138,956	2,138,956	2,138,956	2,138,956	2,138,956

From the first to tenth year, the 19,219,628 bahts of annual sales is forecasted. The annual cost is 16,163,977 bahts derive from the product amounts multiply with sub-contractor outsourcing unit price that is shown in Table 4.4.

Table 4.4. Annual Cost of Goods Sold for Hiring Sub-contractors.

Product Code	Sub-contractor Price (baht/piece)	Amonut (piece)	Total Cost (bahts)
317R-8-0-564-01	0.47	1,253,328	589,064
HU1-A-C-999-09	0.80	3,746,664	2,997,331
HK01-A-C-PF1-09	0.80	3,746,664	2,997,331
NK06-0-0-171-01	2.20	2,026,668	4,458,670
NK06-0-0-999-01	2.20	2,026,668	4,458,670
SS30-1-0-PS0-02	4.80	42,672	204,826
SS30-2-0-PS0-02	4.80	3,072	14,746
TT09-0-0-561-01	5.00	88,668	443,340
Total			16,163,977

From Table 4.3 shows that both taxable income and 5-years cumulative of taxable income are positive values. Therefore, the company must pay 30% tax annually.

4.2 Cash Flow Analysis

When an economic analysis is performed, the analysis should be on a before-tax of after-tax basis. Ordinarily the after-tax analysis may or may not result in a different decision than that from a before-tax analysis. Though the alternative chosen may be the same after-tax analysis, it gives much better estimates of cash flows and the anticipated rate of return for an alternative. For these reasons we will evaluate a purchasing-injector project base upon cash flow after tax approach.

4.2.1 Cash Flow Analysis for Purchasing the Injectors

The cash flow after tax analysis of a purchasing-injector project is tabulated in Table 4.5. There are many terms in cash flow analysis; more details of such terms will be available as follows:

Cash Flow for Purchasing the Injectors.

[illegible]	[illegible]											
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19,219,628	19,219,628	19,219,628
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Maintenance Cost		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tax pay on Capital Gain												[illegible]
Tax(30%)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Cash Flow	[illegible] 000 000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cum. NCF	[illegible] 000 000	[illegible]	[illegible]	[illegible]	5,895,013	11,139,927	16,356,069	23,793,296	31,230,524	38,667,751	46,104,978	54,942,206

Discount Payback Period = 1.42

Cash Flow for Not Purchasing the Injectors.

[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sub-contractor Cost		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Cash Flow	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

From Section 3.5, source of money, the company finances 10 million of own money and 10 million of borrowing from bank that results in annual loan repayment and interest payment through the first 5 years of the project period. To understand the annual loan repayment and interest payment, let's review the loan repayment schedule that is introduced in Section 3.6.

The annual material cost, equal to 7,584,912 bahts, derived from sum of plastic material cost and 7%VAT of plastic material minus with refunded scrap cost (622,795 + 43,596 — 34,315 = 632,076 bahts per month). The annual labor cost is 455,328 bahts comes from the sum of monthly labor cost in machine setting-up process, gate-cutting process and quality control process that equal to 165 bahts, 17,779 bahts and 20,000 bahts, respectively.

The 891,920 bahts annual cost of electricity occurs from the sum of 14,228 bahts annual cost of dryer-electricity and 877,692 bahts annual cost of injector-electricity. To change engine oil costs 40,000 bahts annually and to preventive maintenance costs 480,000 bahts annually become the 520,000 bahts of total maintenance costs annually.

When the termination of the project comes, the salvage value is estimated at 1,000,000 bahts for an injector. It implies that the realized salvage value of the injectors exceeds the book value in year 10 (equal to zero), thus the company has to pay the 30% tax from capital gain that equals 300,000 bahts for an injector or 600,000 bahts for two injectors.

4.2.2 Cash Flow Analysis for Not Purchasing the Injectors

Table 4.6 displays the cash flow after tax for not purchasing the additional injectors. The forecasted annual sales is 19,219,628 bahts. And the annual cost that has the equivalent value with the total sub-contractor cost is 16,163,977 bahts.

4.3 Present Worth Analysis

In this section the evaluation of a purchasing-injector project is treated by the Present-Worth method. The Present-Worth of 2 alternatives: purchasing the injectors or not, is tabulated in Table 4.7 and Table 4.8, respectively.

Table 4.7. Present-Worth for Purchasing-injectors Alternative.

Year	Net Cash Flow
0	**-10,000,000**
1	5,323,868
2	5,298,723
3	5,272,422
4	5,244,914
5	5,216,142
6	7,437,227
7	7,437,227
8	7,437,227
9	7,437,227
10	8,837,227
PW(4.5%) =	38,518,492

Table 4.8. Present-Worth for Not Purchasing-injectors Alternative.

Year	Net Cash Flow
0	0
1	2,138,956
2	2,138,956
3	2,138,956
4	2,138,956
5	2,138,956
6	2,138,956
7	2,138,956
8	2,138,956
9	2,138,956
10	2,138,956
PW (4.5%) =	16,196,126

From 2-preceding tables indicate that the Present-Worth of purchasing the injectors is more than the Present-Worth of not purchasing equals to 22,322,366 bahts (38,518,942-16,196,126). Result in the purchasing-injectors project is accepted.

4.4 Incremental Analysis

When the company has to select only one alternative from the purchasing-injectors or not purchasing-injectors alternative, the incremental cash-flow tabulation between two alternatives can be conducted in Table 4.9.

Table 4.9. The Incremental Cash-Flow Tabulation.

Year	Net Cash Flow (Not Purchasing)	Net Cash Flow (Purchasing)	Incremental Cash Flow
0	0	-10,000,000	-10,000,000
1	2,138,956	5,323,868	3,184,912
2	2,138,956	5,298,723	3,159,767
3	2,138,956	5,272,422	3,133,466
4	2,138,956	5,244,914	3,105,958
5	2,138,956	5,216,142	3,077,186
6	2,138,956	7,437,227	5,298,271
7	2,138,956	7,437,227	5,298,271
8	2,138,956	7,437,227	5,298,271
9	2,138,956	7,437,227	5,298,271
10	2,138,956	8,837,227	6,698,271
		ROR =	34%

For not purchasing-to-purchasing comparison results in the 34% Rate of Return, ROR. Since 34% ROR > 4.5% MARR, which is equivalent to Weight Average Cost of Capital in Section 3.5, the purchasing-injectors project is acceptable.

V. SENSITIVITY ANALYSIS

The previous chapter, applied the Present-Worth analysis and the incremental analysis to evaluate a purchasing-injectors project. The conclusion is such project is acceptable. This is the decision-making based upon the future estimation, which are always incorrect and inaccurate. By using the sensitivity analysis, the effect of variation may be determined.

Some of the parameters that are defined to evaluate the sensitivity of such purchasing-injector projects are MARR, material cost and sales volume. Note that one parameter at a time is varied and independent from other parameters is assumed. This assumption is not completely correct in real-world situation, but it is practical since the ability to accurately account for actual dependencies is not generally possible.

5.1 Sensitivity Analysis on MARR

When MARR is the parameter of interest, the measure of Present-Worth for all sixteen MARR values is presented in Table 5.1. And a plot of MARR versus Present-Worth is shown in Figure 5.1.

Table 5.1. Present-Worth Sensitivity to Parameter MARR.

%Change	Present-Worth
5%	37,068,025
10%	25,497,054
15%	17,770,376
20%	12,464,696
25%	8,729,185
30%	6,039,883
35%	4,065,142
40%	2,589,631

%Change	Present-Worth
45%	1,470,215
50%	609,648
55%	-59,485
60%	-584,802
65%	-1,000,527
70%	-1,331,654
75%	-1,596,705
80%	-1,809,601

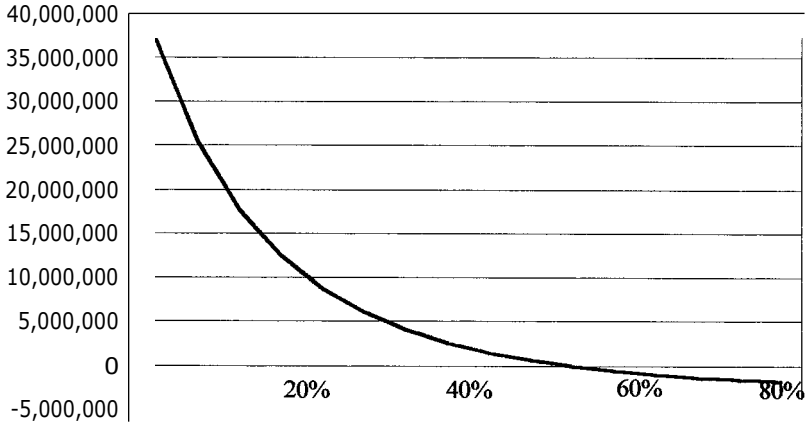


Figure 5.1. Plot of Sensitivity of Present-Worth to MARR.

The above graph demonstrates that the Present-Worth trend is decreasing when MARR trend is increasing. This indicates that the decision to accept the purchasing-injectors project based on Present-Worth is quite sensitive to variations in the MARR. If the MARR is established at more than 54.5%, the investment is not attractive.

5.2 Sensitivity Analysis on Material Cost

In production process, there are 5 types of plastic material. The one-kilogram price of PP-AW564, POM-F2003, PP-AH561, PS-6075 and ABS-KU621 is 37 bahts, 51 bahts, 37 bahts, 68 bahts and 117 bahts, respectively. Table 5.2 shows the 10% increments to evaluate sensitivity on material cost and Figure 5.2 graphically displays the material cost versus Present-Worth.

Table 5.2. Present-Worth Sensitivity to Parameter Material Cost.

%Change	PP-AW564	POM	PP-AH561	PS-6075	ABS	Present-worth
-50%	19	26	19	34	59	59,711,478
-40%	22	31	22	41	70	55,472,971
-30%	26	36	26	48	82	51,234,465
-20%	30	41	30	54	94	46,995,959
-10%	33	46	33	61	105	42,757,452
0%	37	51	37	68	117	38,518,946
10%	41	56	41	75	129	34,280,439
20%	44	61	44	82	140	30,041,933
30%	48	66	48	88	152	25,803,426
40%	52	71	52	95	164	21,564,920
50%	56	77	56	102	176	17,326,413
60%	59	82	59	109	187	13,087,907
70%	63	87	63	116	199	8,849,400
75%	65	89	65	119	205	6,730,147
80%	67	92	67	122	211	4,610,894
90%	70	97	70	129	222	372,387
100%	74	102	74	136	234	-3,866,119

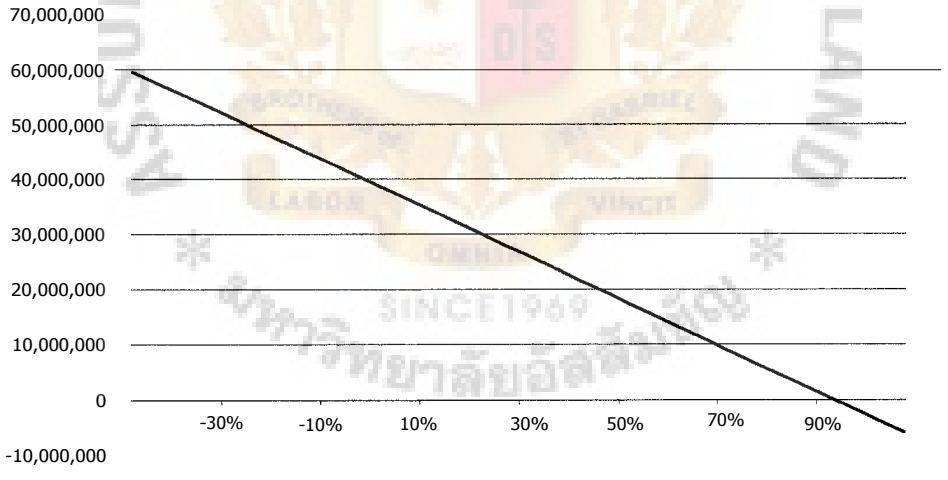


Figure 5.2. Plot of Sensitivity of Present-Worth to Material Cost.

The negative slope of a sensitivity graph in Figure 5.2 indicates that the decision to accept the purchasing-injectors project based on Present-Worth is sensitive to variations in the material cost. The project will be rejected if the material cost increases more than 90% of existing costs.

5.3 Sensitivity Analysis on Sales Volume

A purchasing-injector project deals with 8 product-types and each product type has a unique sales volume that is different in value from each other. This is the reason why the sensitivity analysis on sales volume should be performed not only in overall but also in separate product type.

5.3.1 Sensitivity Analysis on Sales Volume of 317R-8-C-564-01

The existing sales volume of 317R-8-C-564-01 is 1,253,328 pieces annually. Table 5.3 and Figure 5.3 show the Present-Worth sensitivity on sales volume using 10% increments.

Table 5.3. PW Sensitivity to Sales Volume of 317R-8-C-564-01.

%Change	PW
-100%	35,975,638
-90%	36,220,401
-80%	36,475,902
-70%	36,731,543
-60%	36,987,044
-50%	37,242,685
-40%	37,498,187
-30%	37,753,828
-20%	38,009,329
-10%	38,264,970

%Change	PW
0%	38,518,982
10%	38,775,972
20%	39,031,614
30%	39,287,115
40%	39,542,756
50%	39,798,257
60%	40,053,898
70%	40,309,399
80%	40,565,040
90%	40,820,542
100%	41,076,183

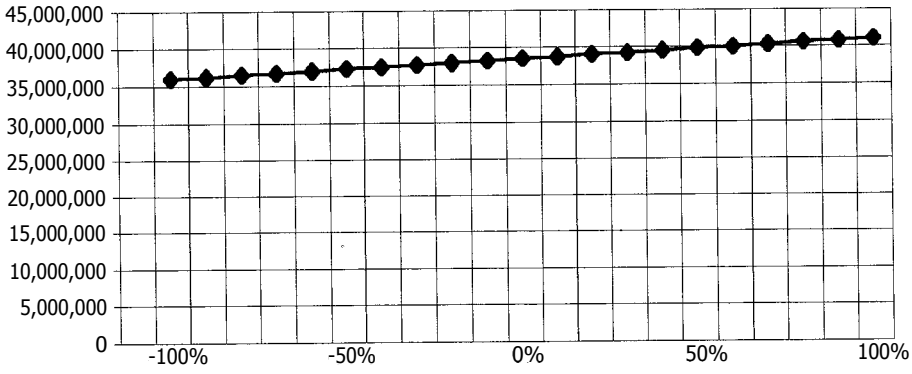


Figure 5.3. PW Sensitivity to Sales Volume of 317R-8-C-564-01.

Figure 5.3 summarize that the decision to purchase the additional injectors is not affected by the sales volume of 317R-8-C-564-01 due to the Present-Worth measures are positive for all values of the changed percentage.

5.3.2 Sensitivity Analysis on Sales Volume of HK01-A-C-999-09& HK01-A-C-PF1-09

Since the product code HK01-A-C-999-09 and HK01-A-C-PF1-09 have the usage-function together, they have the equal annual sales volume. This implies that the increasing sales volume of HK01-A-C-999-09, make the sales volume of HK01-A-C-PF1-09 raised too. Table 5.4 and Figure 5.4 show the Present-Worth sensitivity on sales volume, using 10% increments.

Table 5.4. PW Sensitivity to Sales Volume of HK01-A-C-999-09 & HK01-A-C-PF1-09.

%Change	PW
-100%	13,610,392
-90%	16,081,544
-80%	18,574,932
-70%	21,067,562
-60%	23,560,949
-50%	26,054,337
-40%	28,546,966
-30%	31,040,354
-20%	33,532,984
-10%	36,026,371

%Change	PW
0%	38,519,052
10%	41,012,389
20%	43,475,466
30%	45,999,164
40%	48,491,793
50%	50,985,181
60%	53,477,811
70%	55,971,198
80%	58,464,586
90%	60,957,215
100%	63,450,603

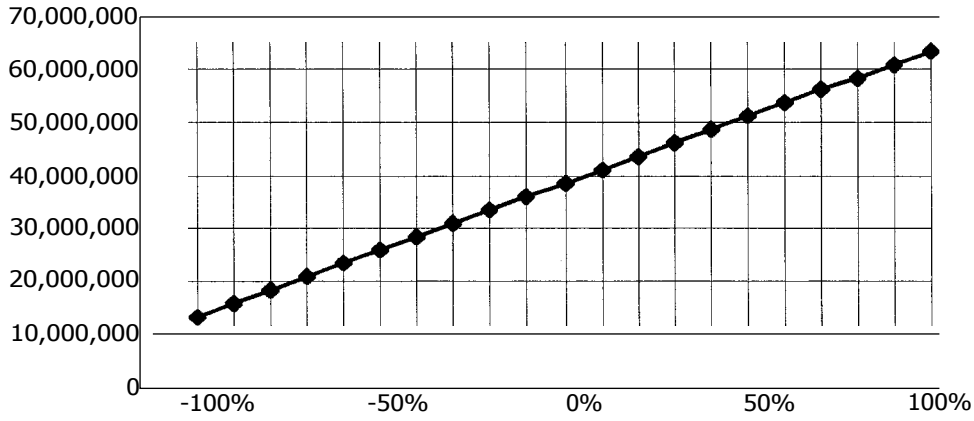


Figure 5.4. PW Sensitivity to Sales Volume of HK01-A-C-999-09& HK01-A-C-PF1-09.

Since the Present-Worth measure is positive for all %changes of sales volume of 111(01-A-C-999-09 and HK01-A-C-PF1-09, their sales volume do not affect the decision to accept the purchasing-injectors project.

5.3.3 Sensitivity Analysis on Sales Volume of NK06-0-0-999-01 & NK06-0-0-171-01

The annual sales volume of NK06-0-0-999-01 equals to NK06-0-0-171-01 because they had to be used together. This means that the decreasing sales volume of NK06-0-0-999-01 will simultaneously incur with the reducing sales volume of NK06-0-0-171-01. The Present-Worth sensitivity on 10% incremental sales volume is shown in Table 5.5 and Figure 5.5.

Table 5.5. PW Sensitivity to Sales Volume of NK06-0-0-999-01 & NK06-0-0-171-01.

%Change	PW
-100%	10,965,945
-90%	13,701,802
-80%	16,459,755
-70%	19,217,709
-60%	21,975,662
-50%	24,732,996
-40%	27,490,950
-30%	30,248,903
-20%	33,006,857
-10%	35,764,810

%Change	PW
0%	38,518,987
10%	41,280,098
20%	44,038,051
30%	46,796,004
40%	49,553,339
50%	52,311,292
60%	55,069,245
70%	57,827,199
80%	60,584,533
90%	63,342,487
100%	66,100,440

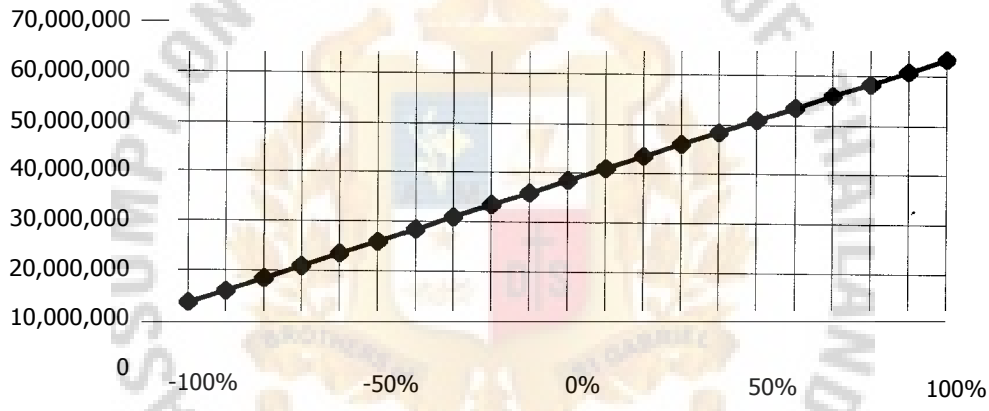


Figure 5.5. PW Sensitivity to Sales Volume of NK06-0-0-999-01 & NK06-0-0-171-01.

Either sales volume increasing 100% or decreasing 100%, the Present-Worth always shows the positive values. In conclusion, the acceptance of a purchasing-injectors project is insensitive to variation in sales volume of NK06-0-0-999-01 and NK06-0-0-171-01.

5.3.4 Sensitivity Analysis on Sales Volume of SS30-1-0-PS0-02

The annual sales volume of SS30-1-0-PS0-02 is 42,672 pieces. Table 5.6 and Figure 5.6 display the measure of Present-Worth for all-20 sales volumes.

Table 5.6. PW Sensitivity to Sales Volume of SS30-1-0-PS0-02.

%Change	PW
-100%	38,349,039
-90%	38,356,325
-80%	38,374,349
-70%	38,392,373
-60%	38,410,397
-50%	38,428,420
-40%	38,446,991
-30%	38,465,015
-20%	38,483,039
-10%	38,501,063

%Change	PW
0%	38,518,982
10%	38,537,657
20%	38,555,681
30%	38,573,705
40%	38,591,729
50%	38,609,753
60%	38,628,324
70%	38,646,348
80%	38,664,371
90%	38,682,395
100%	38,700,419

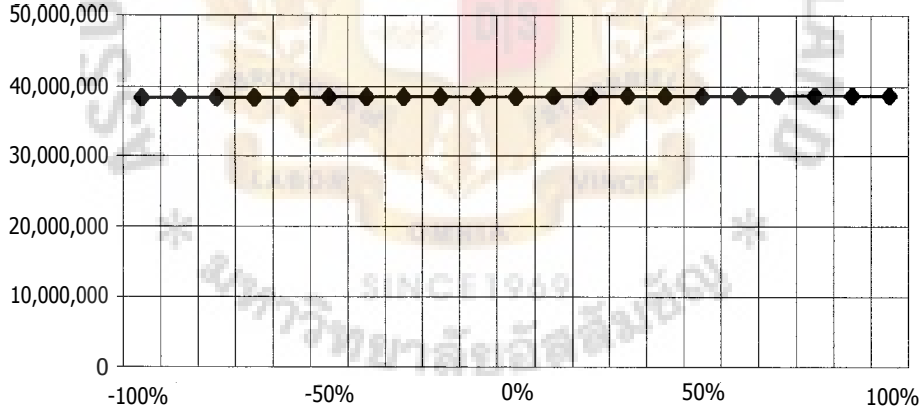


Figure 5.6. PW Sensitivity to Sales Volume of SS30-1-0-PS0-02.

The Present-Worth response curve is flat and approaches horizontal over the range of changed-percentage for sales volume of SS30-1-0-PS0-02. This means that the decision to purchasing the additional injectors is not affected by the sales volume of SS30-1-0-PS0-02.

5.3.5 Sensitivity Analysis on Sales Volume of SS30-2-0-PS0-02

The annual sales volume of SS30-2-0-PS0-02 is 3,072 pieces. Table 5.7 and Figure 5.7 show the 10% increments to evaluate sensitivity on sales volume of SS30-2-0-PS0-02.

Table 5.7. PW Sensitivity to Sales Volume of S530-2-0-PSO-02.

%Change	PW
-100%	38,516,151
-90%	38,506,765
-80%	38,508,117
-70%	38,509,470
-60%	38,510,822
-50%	38,512,728
-40%	38,511,515
-30%	38,513,252
-20%	38,514,990
-10%	38,516,727

%Change	PW
0%	38,518,988
10%	38,520,726
20%	38,522,464
30%	38,524,102
40%	38,525,454
50%	38,527,360
60%	38,528,713
70%	38,530,065
80%	38,531,418
90%	38,532,770
100%	38,534,676

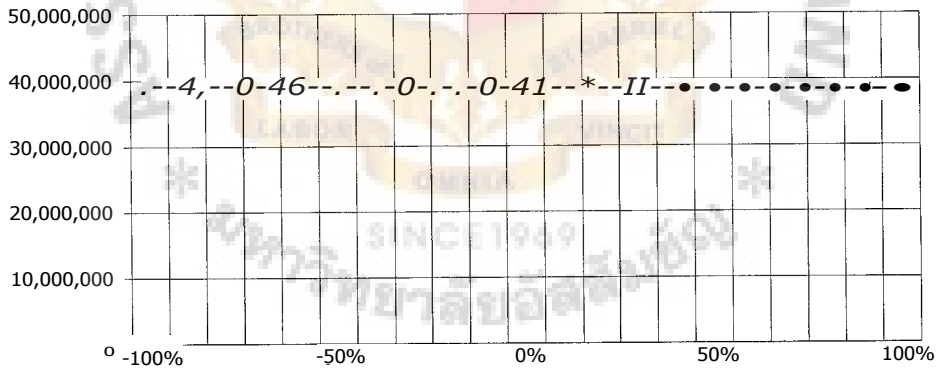


Figure 5.7. PW Sensitivity to Sales Volume of SS30-2-0-PS0-02.

The Present-Worth response curve nearly parallels the %change-axis over the range of variations in sales volume of SS30-2-0-PS0-02, it indicates that there is insensitivity of project-acceptance to sales volume of SS30-2-0-PS0-02.

5.3.6 Sensitivity Analysis on Sales Volume of TT09-0-0-561-01

The annual sales volume of TT09-0-0-561-01 is 88,668 pieces. The Present-Worth sensitivity on sales volume of TT09-0-0-561-01 is shown in Table 5.8 and Figure 5.8.

Table 5.8. PW Sensitivity to Sales Volume of TT09-0-0-561-01.

%Change	PW
-100%	37,896,614
-90%	37,949,028
-80%	38,012,772
-70%	38,075,924
-60%	38,139,668
-50%	38,202,820
-40%	38,266,564
-30%	38,329,716
-20%	38,393,460
-10%	38,456,612

%Change	PW
0%	38,518,986
10%	38,583,509
20%	38,647,252
30%	38,710,996
40%	38,774,148
50%	38,837,892
60%	38,901,044
70%	38,964,788
80%	39,027,940
90%	39,091,684
100%	39,154,837

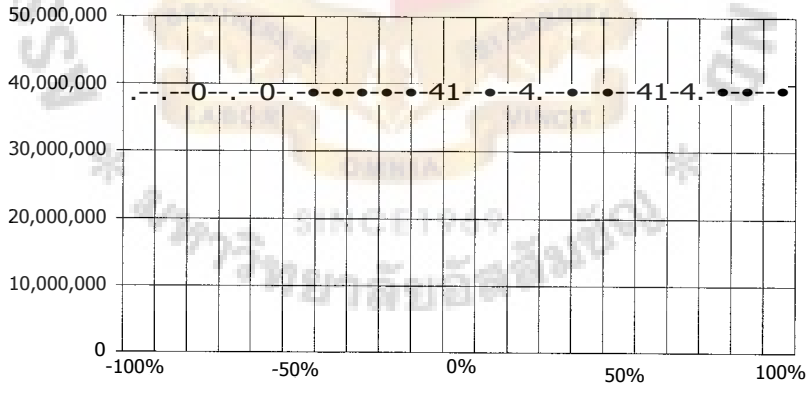


Figure 5.8. PW Sensitivity to Sales Volume of TT09-0-0-561-01.

The Present-Worth response curve is flat and approaches horizontal over the range of changed-percentage for sales volume of TT09-0-0-561-01. In conclusion, the sales volume of SS30-1-0-PS0-02 does not affect the decision to purchasing the additional injectors.

5.3.7 Sensitivity Analysis on Overall Sales Volume

The sensitivity analysis on overall sales volume refers to variation in all 8-product types simultaneously, which are presented in Table 5.9 and Figure 5.9.

Table 5.9. PW Sensitivity to Overall Sales Volume.

%Change	Present-Worth
-100%	-17,281,145
-90%	-12,217,505
-80%	-7,065,989
-70%	-1,915,682
-60%	3,235,834
-50%	8,386,833
-40%	13,535,572
-30%	18,687,022
-20%	23,838,166
-10%	28,989,615

%Change	Present-Worth
0%	38,519,052
10%	39,292,520
20%	44,414,252
30%	49,596,363
40%	54,746,051
50%	59,898,121
60%	65,048,974
70%	70,200,491
80%	75,350,936
90%	80,501,695
100%	85,653,313

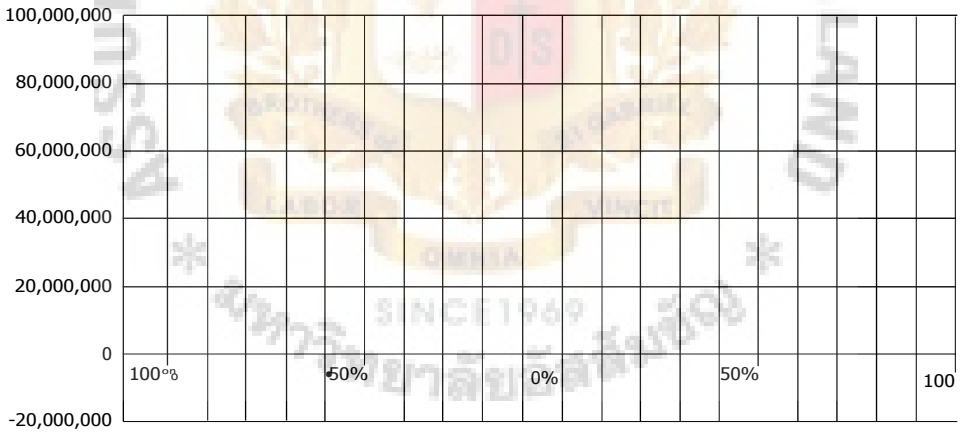


Figure 5.9. PW Sensitivity to Overall Sales Volume.

The positive slope of the Present-Worth response curve indicates that the decision to accept the purchasing-injectors project based on Present-Worth is quite sensitive to variation in the overall sales volume. And the project is still attractive unless the sales volume reduction is greater than 68%.

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The main objective of this study is to analyze the feasibility of purchasing the additional injectors in lieu of hiring sub-contractors.

In the beginning of feasibility analysis the estimation of the product amount from surveying the past sub-contractor outsourcing orders is conducted in order to perceive the additional costs of company's self-injection. The examples of additional costs are material cost, labor cost, electricity cost, maintenance cost and etc. Then applying the Present-Worth analysis and incremental analysis to be the criteria in evaluating the worth of company's self-injection

The Present-Worth of purchasing and not purchasing is 38,518,492 bahts and 16,196,126 bahts, respectively. The Present-Worth of purchasing the injectors is more than the Present-Worth of not purchasing which equals to 22,322,366 bahts. Therefore it is more economical to purchase the additional injectors in lieu of hiring sub-contractors. The result of incremental approach is the same as the Present-Worth approach due to the not purchasing-to-purchasing comparison Rate of Return is 34% >4.5% MARR.

In the last feasibility analysis there is the sensitivity analysis to parameter MARR, material cost, separate sales volume and overall sales volume. The result is that the decision to accept the purchasing-injectors project is sensitive to parameter MARR, material cost and overall sales volume. If the MARR is greater than 54.5% or the material cost increasing is more than 90% or the overall sales volume reducing is more than 68%, the purchasing-injectors project becomes not attractive.

6.2 Recommendations

Throughout this feasibility study relied upon the average sales volume of 8-product types only during January to September 2001. It is quite a short time for collecting the data to be the forecasted product amounts in evaluating the project. Moreover, the additional costs from the investment such as material cost, labor cost, electricity cost, maintenance cost and etc. are very complicated to estimate more closely.

There are many alternatives that are overlooked in this study. These alternatives may be more economical and worth than two analyzed-alternatives: purchasing and not purchasing the additional 150-ton injector alternative. The first example of many alternatives is that the UC Company may survey the new sub-contractors that propose the lower prices than the existing sub-contractor prices. The second example is the indeed-derivation study of sub-contractors outsourcing. This means that sometimes the additional customer orders, which cause to hire sub-contractors, may be products that take 25-ton, 30-ton, 50-ton, 55-ton, 75-ton, 80-ton or 100-ton rather than 150-ton injectors. But when these seven injector capacities are too busy and can not handle the production, the 150-ton injectors will be utilized to produce those workloads instead. Therefore if the derivation study identifies that the additional products do not really take 150-ton injectors in production, other injector capacities can be considered for purchase rather than 150-ton injectors.

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