INVESMENT RISK ASSESSMENT IN PLASTIC INJECTION MOLDING MACHINE REPLACEMENT

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
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ชนินทร์ เหมกมล: การประเมินความเสี่ยงในการลงทุนปรับเปลี่ยนเครื่องฉีดพลาสติก (INVESTMENT RISK ASSESSMENT IN PLASTIC INJECTION MOLDING MACHINE REPLACEMENT). อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. สุทัศน์ รัตนเกื้อกังวาล, 95 หน้า.

งานวิจัยมีจุดประสงค์เพื่อที่จะศึกษาความเสี่ยงในการลงทุนทดแทนเครื่องฉีดพลาสติกในกระบวนการผลิตเปลือกแบตเตอรีของโรงงานผลิตเปลือกแบตเตอรีแห่งหนึ่งซึ่งมีต้นทุนการผลิตที่สูงขึ้นอย่างต่อเนื่อง ซึ่งส่งผลให้ความสามารถในการแข่งขันและกำไรของบริษัทลดลง

เมื่อได้ทำการระบุความต้องการของงานวิจัยแล้ว จึงได้ทำการศึกษาข้อดีข้อเสียของกระบวนการผลิตเปลือกแบตเตอรีเดิม เปรียบเทียบกับกระบวนการผลิตแบบใหม่ โดยวิเคราะห์อายุใช้งานที่คุ้มค่าทางเศรษฐศาสตร์ ต้นทุนคุณภาพในการผลิต อัตราส่วนผลประโยชน์ต่อต้นทุนส่วนเพิ่ม รวมทั้งทำการศึกษาความเป็นไปได้ในการลงทุนกระบวนการผลิตแบบใหม่ ผลจากการวิเคราะห์พบว่ากระบวนการผลิตเปลือกแบตเตอรีแบบใหม่มีความเหมาะสมในการทดแทนกระบวนการผลิตเดิม โดยกระบวนการผลิตแบบใหม่มีอัตราการคืนทุนที่ 10 เดือน โดยมูลค่าปัจจุบันสุทธิของโครงการอยู่ที่ 747 ล้านบาท หลังจากนั้นได้ทำการวิเคราะห์และประเมินความเสี่ยงที่อาจมีผลกระทบต่อกระบวนการผลิตเปลือกแบตเตอรีแบบใหม่ โดยสามารถระบุความเสี่ยงได้ทั้งหมด 14 รายการ ตลอดจนได้ทำการวิเคราะห์ความเสี่ยงวิกฤตโดยใช้เทคนิคพาเรโต้ ซึ่งสามารถระบุความเสี่ยงวิกฤตได้ 3 รายการ ซึ่งประกอบไปด้วยความผันผวนของราคาวัตถุดิบ ความผันผวนของราคาสินค้า และภาวะถดถอยของตลาดสืบเนื่องจากภาวะเศรษฐกิจ หลังจากนั้นจึงได้จัดทำมาตรการป้องกันความเสี่ยง 4 มาตรการซึ่งสามารถบรรเทาความรุนแรงของความเสี่ยง ซึ่งได้แก่ การพัฒนาบุคลากร การสื่อสารระหว่างบริษัทกับลูกค้าและผู้ผลิตวัตถุดิบ และการประชุมร่วมของแผนกที่เกี่ยวข้อง แม้ว่าได้มีการเตรียมมาตรการป้องกันความเสี่ยงไว้แล้วนั้น การติดตามผลการดำเนินการบริหารความเสี่ยงยังคงต้องดำเนินการอย่างต่อเนื่อง

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The purpose of this research is to assess investment risk in plastic injection machine replacement in a company that its production cost is increasing continuously which causes company to lose competitive advantage and profit margin.

Under the given research requirements, the machine replacement analysis is conducted by comparing existing production system with new production system in various aspects consisting of economic life cycle analysis, cost of quality analysis, incremental B/C ratio analysis, feasibility study and risk assessment of new production system. The results of these analysis show that it is appropriate to replace the existing system with the new one. The payback period of the new production system is about 10 months with 747 million baht of net present value.

In addition, risks that might affect the new production system are identified and evaluated. By using Pareto technique, 3 critical risks out of 14 preliminary identified risks have been determined. They are raw material price fluctuation, product price fluctuation and market recession. Then the risk team has generated 4 preventive action plans which are skill training, communication between the company and its customers as well as its raw material suppliers and cross-department meeting. Although the preventive action plans have been generated, the risk management has to be monitored and controlled continuously.

Regional Centre for Manufacturing System Engineering Student's signature……...
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Contents

Page

List of Tables

Page

List of Figures

Page

Chapter I
Introduction

To run business in competitive market these days, company has to develop themselves continuously especially their core competency in order to maintain their competitive advantages. For plastic and melamine markets, short lead time, low price and high quality is the key success of winner of these markets. Moreover, technology is one of important aspect that affect to the competitive advantages. It is not possible for general manufacturing with existing technology, to meet customer's requirement in specific segment. In order to keep up their competitive advantages, company has to invest in hi-tech manufacturing system.

In order to achieve competitive advantages, company can invest in many aspects such as human resources, technology, operation management and etc. Behind those aspects, the company has to spend one important resource which is money in order to develop each aspect. All the investment especially in the manufacturing industry will summarize into two factors which are finance and operation. These two factors play an important key role in business.

At the present, there are many situations that happen and affect around the world such as global warming, political situation and etc. But the situation that mostly affects to economic and business around the world is financial crisis (Hamburger crisis) and crude oil price crisis. Both crises affect to every sector of the business, therefore, if the company make unsuitable decision, the company will encounter business crisis.

To avoid business crisis, it is important that company should plan out a feasibility study of each investment. Feasibility study is a good tool that company can use to analyze company position in micro and macro environment and also focus on forecasting into the future in order to know that the project is worth for investment.

1.1Research Background

Plastic industry is a competitive industry in Thailand and important to domestic economic. Plastic industry generates revenue about 10,000 million baht per year. Moreover, plastic industry is a downstream chain of petrochemical industry

which transforms plastic pellets into plastic products. In 2003, there are 4,560 plastic plants that registered with industrial department which mostly are small and medium enterprise. According to world oil price crisis in 2003, this situation affected to plastic industry badly because of core material that uses in plastic industry is a plastic pellet that make from crude oil through petrochemical industry. So when crude oil price expensive, plastic pellet price also expensive too. This situation can reduce competitive advantage to domestic manufacturing. The structure of plastic industry in Thailand can be shown as

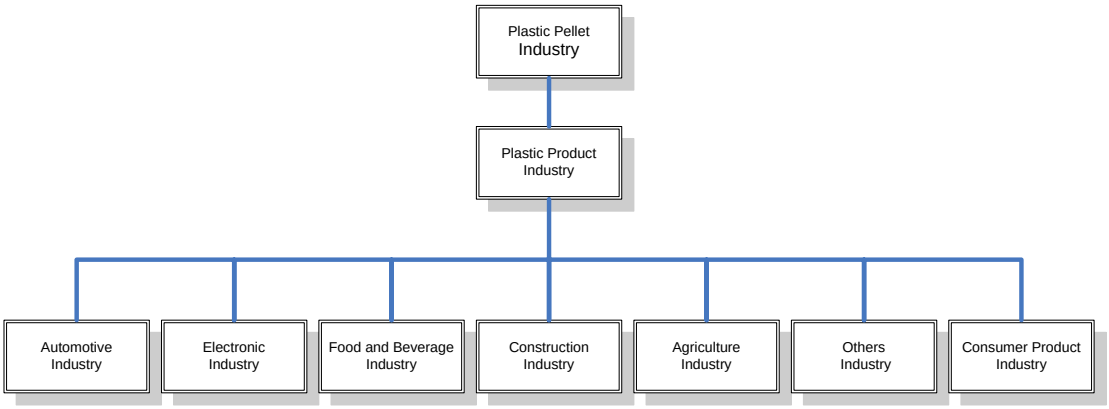

Figure 1.1 Thailand's Plastic Industry Structure

Source: Study of Energy Consumption in Plastic Industry, Department of Alternative Energy Development and Efficiency, 2006

ABC Company is a leading company in plastic industry in Thailand. The company was founded in 1963 ran business in household plastic products industry. The company had growth and prospers with the plastic industry and came through the economic crisis in 1997. In 2006, the board of director decided to restructure the product portfolio of the company into Industry and Household product segment, trading segment and supporting segment. The company's products can divide into 2 major categories which are;

- Melamine product such as tableware, children ware, airline tray, toilet ware, ashtray and etc.
- Plastic product such as OEM parts for electric appliance, palette, furniture, food packaging, battery case and etc.

Figure 1.2 Melamine and plastic products of the company

At the present the company has revenue about 5,500 million baht which most of the revenue come from domestic market. The company has 5 subsidiary companies, 12 partner companies and a joint venture company with 4 factories in Thailand, 1 factory in Vietnam and 1 factory in China. The company exports their products to 90 countries around the world and in the next year the company plans to export their products to 100 countries around the world.

In 2008, during Hamburger crisis, board of director asked the engineering department to improve the production process and reduce cost such as production cost, operation cost and etc. After studying, board of director approve in principle to combine 2 production lines together in order to increase efficiency of production.

The company, with the engineering team conducted consolidate action plan, the company found many disadvantages of two existing production systems because the production system was operating by 15 injection machines that have been used for 20 years. The disadvantages of existing machine are

- High operation cost
- High maintenance cost
- High waste
- Long lead time for production
- High energy consumption

According to those disadvantages, the company found that the existing production system was not suitable in order to achieve the target. The company decided to study alternative production system in order to replace the existing. The company found that the production system can be operated by smaller machine because the production system needs only 300 Tons clamp force in holding process but existing machines can provide 450 Tons clamp force so machines consume a lot of energy but low production rate. So the company decided to replace machines by using smaller machines that can provide low energy consumption and twice of production rate. The original injection molding machine specifications compare with candidate machine as following;

Table 1.1 shows comparison of original injection machine with its candidate.

Information	Defender	Challenger
Brand	**Meiki 450T**	**Husky 300T**
Origin	Japan	Canada
Type	Hydraulic Machine	Hylectric Machine
Clamp Force (Tonne)	450	300
Screw Diameter (mm)	65	80
Injection Capacity (cm3)	995	1759
Injection pressure (kg/cm3)	1640	1550
Injection Flow Rate (g/sec)	250	2200
Plasticizing Rate (kg/hr)	250	350
Screw L/D ratio	20	21.7
Motor Pump Power (Kw)	55	55
Heater Power (Kw)	21.7	42
Expected Useful life	≥10 years	≥10 years
Power consumption (Kwh/Kg)	1.2	0.8
Average Scrap Rate	1%-2.5%	0.5%

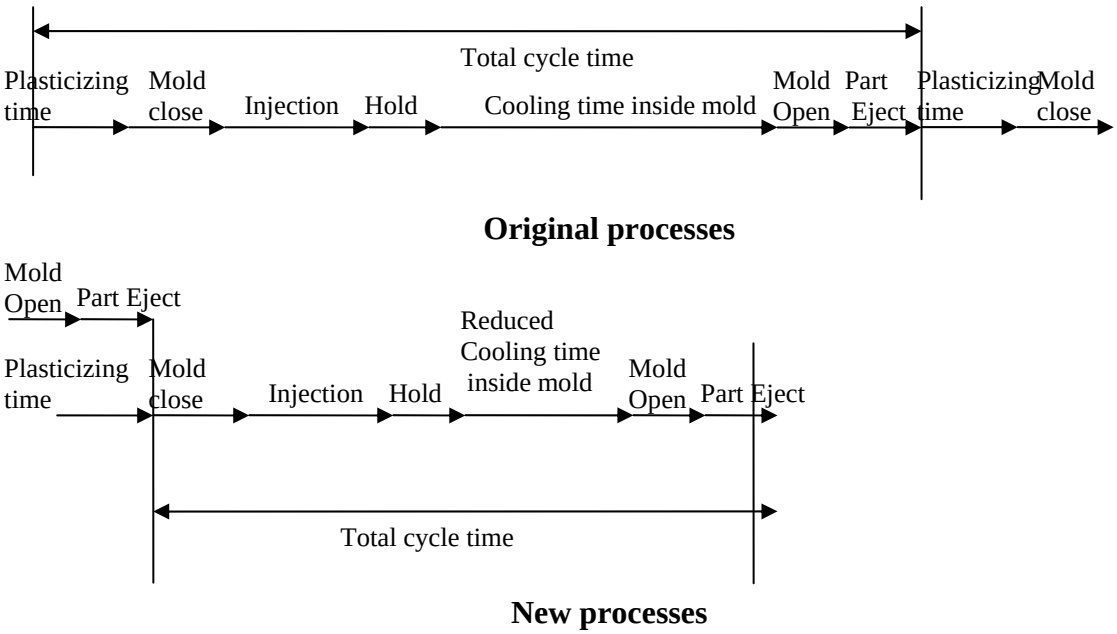

Figure 1.3 Comparison of Original battery case processes with new processes

In the original processes, it spends a lot of resource along the process because of long cooling time inside mold. In cooling time process, Injection molding machines consume a lot of energy consumption while holding the mold. In order to reduce energy consumption, the engineering team of company suggests that team can reduce production cycle time that spend in machine by eject the product early and cooling it outside of the mold. This methodology does not only reduce energy consumption of machines but also increase the production rate. To apply this methodology into real processes, the company has to change the machines that offer higher performance but consumes lower resources. This development project can develops core competence and increases competitive advantages of the company.

Because of financial crisis that widespread around the world, the company has to make a carefully movement even though the company has the strength in financial and cash flow. But in every crisis situation, it still has opportunities. In order to achieve opportunities, the company has to know what to do in order to increase their competitive advantages. Behind the development of the process, there are a lot of risk that can happen after the investment and also can provide the failure of the project investment so the company has to plans out a study before making a decision in development project in order to make sure that company can achieve maximum benefits and prepare the contingency plan after the project has been employed.

1.2Statements of Problems

According to the original battery case processes consume a lot of resources, those resources are;

- Production cycle time
- Energy consumption
- Wastes
- Workforces

The engineering team investigated the process and found that production time cycle time can be reduced by about 50%.(by applying new processes concept) The company decided to apply new concept of the processes that can improve the production line in high efficiency and high productivity. In order to apply new concept to the processes, the company has to invest in the replacement of the injection molding machines.

In developing the project that company decided to invest, there are many aspects that company should concern before investing. Several aspects that affected to the investment project are;

1. Control factors that provide theory development target
2. Economic life cycle, operation and maintenance and cost of quality of both machine
3. Benefit of the development project
4. Risk that might affects to the project

In order to achieve maximum benefits from the investment, the company plans out **Investment Risk Assessment in Plastic Injection Molding Machine Replacement.**

1.3Research Objectives

To analyze investment risk in Plastic Injection Molding Machine Replacement in order to determine project feasibility and generate preventive plans to avoid risk.

1.4Research Scopes

The research scopes of this study are;

1. This thesis focuses on Plastic Injection Molding Machine Replacement

2. Studying effectiveness and efficiency in technical aspects of candidate technology in order to compare with the old machine.
3. Studying feasibility investment by using the replacement analysis.
4. Identify risk that affected the development of the project

1.5Expected Benefits

The expected benefits that achieve from Investment Risk Assessment in Plastic Injection Molding Machine Replacement are;

- The company acknowledges that the investment project is worthwhile.
- The company can increase competitive advantages.
- The company can reduce energy consumption in battery case processes.
- The company can increases the efficiency and productivity of the processes.
- To avoid investment risk that affected to the development project

1.6Research Methodology

1. Study applied theories and other researches that related to study.
2. Collect data of the original processes and related information.
3. Study candidate technology in technical aspects.
4. Identify control factors that provide theory development target.
5. Evaluate and identify proper development target.
6. Analyze economic life cycle, operation and maintenance and cost of quality in both machine.
7. Study feasibility of investment project.
8. Identify investment risk of the project.
9. Summarize and conclusion the analysis.
10. Write up the thesis.
11. Submission and present the thesis.

Chapter II

Related Theories and Frameworks

In order to study and analyze the on investment project, there are a lot of theories and literature that provide necessary framework for the study. In this chapter, it will cover all of theories and literature that are useful for the study and develop the framework further to match with study requirement in order to provide appropriate solution and justification.

2.1 Theoretical concept

Reasons behind machine replacement are obsolescence of existed machine, process improvement, advance technology required for production, new production technology and etc. In order to study investment risk assessment in machine replacement, the company has to know when the investment should be implemented. There are 4 main theoretical frameworks which are economic life cycle, cost of quality, feasibility study and risk management.

2.1.1. Economic life cycle

Obsolescence of machine is a reason behind the machine replacement investment. In order to evaluate the existing production system, economic life cycle analysis or economic service life is a useful tool that helps the company to analyze existed system whether reaches optimum service life or not. Moreover, this framework can be used to evaluate economic service life of alternative system.

Economic life cycle is a framework that uses to estimate number of year which the total annual worth cost is the minimized. If evaluated system reaches economic life cycle, so the system should be replaced in order to minimize total annual cost. Economic life cycle can be determined by calculating total annual cost which includes capital recovery, which equals to annual worth of initial investment capital and salvage value, and the annual worth of estimated annual operation cost. The total annual worth calculation is found by equation:

Total AW = -Capital recovery (CR) – Annual worth of annual operation cost

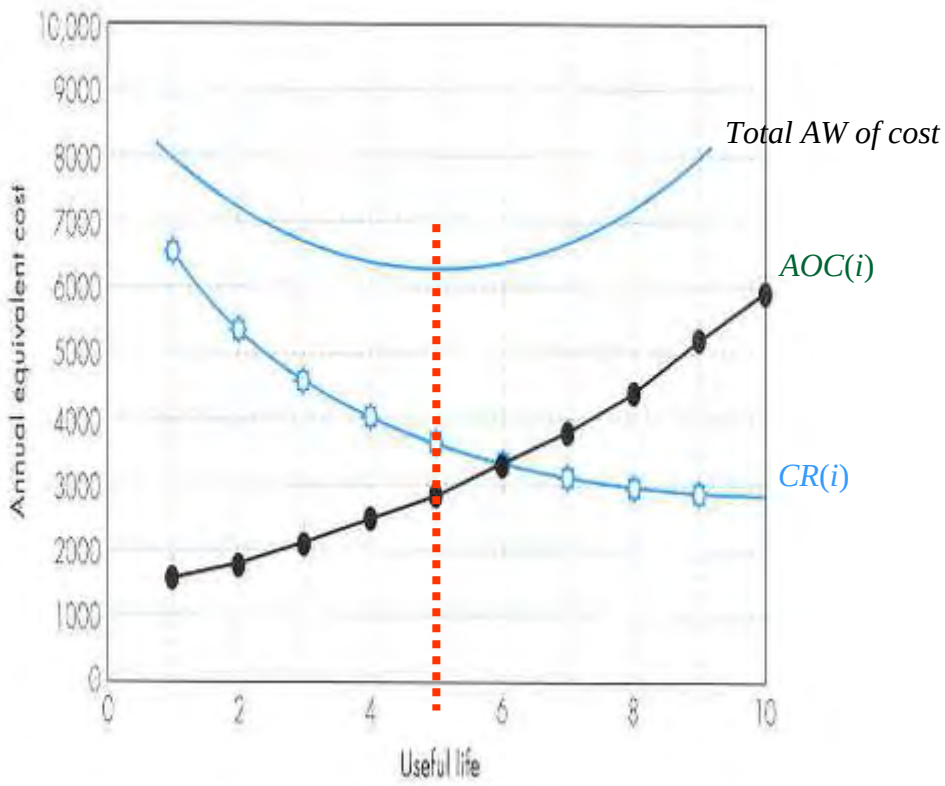

Figure 2.1 Total AW of cost determine the economic life cycle

Source: Contemporary Engineering Economics, 4th edition, 2007

The economic life cycle is a number of years that total annual worth of cost is minimized. As you can see in the figure 2.1, the capital recovery decreases while annual operation cost increases. The capital recovery and annual operation cost can be calculated by using equation as follows.

$$Captial\ \text{Recovery} \quad = \quad -P(A/P,i,n) + S(A/F,i,n)$$

$$Annual\ Worth\ of\ \ Annual\ operation\ \text{cost} \quad = \quad -\left[\sum_{n=1}^{n=k} AOC_j(P/F,i,n)\right](A/P,i,k)$$

Where P = Investment capital

S = Market value of assets at the end of the year

i = Minimum attractive rate of return (MARR)

n = Number of study period

$$Total\ AW_k = -P(A/P,i,n) + S(A/F,i,n) - \left[\sum_{n=1}^{n=k} AOC_j(P/F,i,n)\right](A/P,i,k)$$

Note: Asset's market value at the end of the year an be used as salvage value in each year.

$$A/P = \frac{i(1+i)^n}{(1+i)^n - 1} \Rightarrow Capital\ recovery\ factor$$

$$A/F = \frac{i}{(1+i)^n - 1} \Rightarrow Sinking\ fund\ factor$$

2.1.2. Cost of Quality

The cost of quality framework is a useful tool to analyze cost that related to quality of production system. Cost of quality is evaluated into currency. The comparison of cost of quality between defender system and challenger system will provide support information in order to make decision in machine replacement investment. Cost of quality can be defined into 4 categories of cost which are

Table 2.1 Cost of quality category and examples

COQ Category	Description	Example
Internal failures cost	**Costs related to deficiencies of discovered products before delivery**	**Scrap, Rework, Retest, Machine broke down, loss in process and etc.**
External Failures cost	**Costs related to deficiencies of discovered products after delivery**	**Return materials, Warranty, After sale services, lost of opportunity due to quality and etc.**
Appraisal cost	**Costs related to measurement and assessment quality of the system**	**Quality control system, measuring devices, data collection system, and etc.**
Prevention cost	**Cost related to prevent the losses in the future**	**Preventive maintenance, Process planning, Quality assurance, and etc.**

2.1.3. Feasibility study

Feasibility study is required in order to make sure that company can achieve maximum benefits from development project, because the study provide required information in several aspects that the company has to concern before deciding on investment project. According to Jiramahakarn(2001), the feasibility study is about setting up an airline of Aerothai which focused on 3 main aspects, marketing, engineering and financial aspect. Moreover, in Machine Replacement in Cooking Oil Bottling Process, Teoh Kah Boon(2001), the study provide information in 3 main aspects, marketing, technical and financial aspects. Even those 3 aspects seem like to be required for feasibility study but not every study that concern on those. According to Decision analysis for the polyester filament yarn plant selection for mosquito nets industry, Kobkanjanakorn(1999), in this study make a different from other which focused on engineering, management, and finance aspects in order to make decision. In addition, according to Isarabhakdi (1999), Economic decision for selecting an appropriate by-product upgrading technology**,** this study focused only 2 aspects which are economic and technology aspect. So there is no pattern that feasibility study should contain but the study has to provide necessary information for decision making.

In this study, the feasibility study will concern in main 2 aspects which are marketing, financial aspects in order to make decision that the improvement project is investing on the right time with appropriate alternative.

- **Market feasibility**

  In this aspect, the study will focus on the market status, market potential and company status in the market. In order to know that there are opportunities available in the market by looking on market demand and price trend. This information is required in order to know that the market in the future does not recess during improvement program and there are opportunities available for the company.

- **Financial feasibility**

  In this aspect, the study will focus on the benefits of the investment. In order to analyze financial feasibility, the simple measurements that concerned are return on capital employed, pay back period, net present

value and internal rate of return. The above measurements are suitable for the project that has low capital investment and short period of project life span. For the large capital investment project that has long project life span, the life cycle cost analysis is required.

Return on Capital Employed

ROCE is a financial ratio that uses to measure the generated returns of the project compare with capital employed. This ratio formulation as following;

$$\text{ROCE} = \frac{\text{Profit before tax (EBIT)}}{\text{Capital Employed}} * 100$$

Payback period

Pay back period is a simple tool that used to calculate that how many years the project take in order to repay the investment budget. So shorter period of payback is more prefer than longer period. Because of similarity of this tools lead the limitation. This tool does not concern in other financial aspects such as interest, value of the money, and etc. So this tool can be use as guideline in order to make a decision.

Net Present Value

Net Present Value is a tool that uses to calculate the present value of the project along the project lifetime. It is suitable for long-term investment. This tools concern in value of money that change along the project. So the company can know the profitability of the project along the project lifetime and evaluate with value of the money.

Internal rate of return

Internal Rate of return is a ratio that used widely in the business because this ratio can show the efficiency of the investment. This ratio is similar to Net Present Value but has a little different. This ratio indicates the efficiency of the project in percentage, not value of money.

2.1.4. Risk Management

Risks are uncertainty situations which provide impacts to project and company in good way and bad way. No matter how big of the project or company, in order to success, all risks have to be considered. So risk management became a seriously aspect in corporate for decade because risk management is a framework which is used to identify and evaluate what are risk that impact to company and industry and is also prepared the organization to generate prevention and response protocol. In order to conduct risk management, there are 4 steps as followings

1. **Risk Identification**

   Risk identification is a process that uses to identify risk events which might be opportunity impact and threat impact to the project. In this case, the investment risk assessment project will focus only threat impacts that affects to the project. In risk identification process, risk management team will try to forecast all the risks that might happen. Risk identification can be separated into 2 types which are proactive identification and reactive identification. Proactive identification is identification technique which all risks come from imagination and forecasting from experiences which is difficult because of inequity of person in interesting, expertise, experience and thinking method so it will be difficult and sensitive to judge. Because of limitation of forecasting risk, reactive risk identification will be applied after decision making. It means that reactive risk identification will be conducted during implement stage of project.

2. **Risk Assessment**

   After all risks have been identified, the risk assessment is needed in order to evaluate impact of each risk that identified. The risk assessment can be separated into 2 types which are quantitative risk and qualitative risk. The difference between quantitative risk and qualitative risk is quantitative risk determines severity by using number but qualitative risk determines severity by using workings. There are many risk assessment tools. To select assessment tools, it depends on type of risks. Difference type of risk has different approach and methodology to assess. There are some useful risk assessment tools as following

- Portfolio Management
- Investment Analysis
- Decision Analysis
- Failure Mode and Effect Analysis (FMEA)
- Monte Carlo Simulation

3. Risk Management Planning

Once risk assessment has been conducted, risk management planning is needed in order to decide how to manage or response to the risk. Some risks do not needed to manage because of very low impact or insufficient resource. In order to decide how to response to the risks, there are 4 strategies to apply as following

- **Risk Elimination**

  Risk Elimination can be as called risk avoidance or risk aborting. This response is totally elimination due to high possibility of severity impact but eliminating risk also come with losing out the potential benefit that retaining risk may have allowed.

- **Risk Reduction**

  Risk reduction response is to reduce the severity or occurrence of the risk by gathering information about the risk. This response is more preferable than risk elimination.

- **Risk Transfer**

  Risk transfer can be referred as risk sharing. This response is to transfer risk to third party such as insurance or outsourcing. This response is commonly used in business. This response is tried to transfer the risk to other partner that linked to the project. In order to transfer risk effectively, risk should be transfer to expertise or experienced organization.

- **Risk Retention**

  Risk retention is the last response that risk management team will choose because this response is to accept or absorb the risk. The reason behind choosing this response is there is no other way to manage the risk. The risk that should be response with risk retention is the risk that has low severity impact to the project.

After decided the response to the risk, contingency plan and preventive method is conducted in order to manage the risks. The contingency plan and preventive method is a procedure that uses to protect and prevent the risk to occur again.

4. Monitoring & Review

At the end of the risk management process, the monitoring and review process is required. Because the risk management program that conducted at first time is never be prefect. The monitoring is required in order to collect information about actual results of the risk management program and then review in order to adjust and correcting the analysis and contingency plan due to necessitate change.

Chapter III
Investment Project Background and investment risk assessment process

In this chapter provides information about the background of the investment project by covering information about the investment project background, the original production processes of battery case production, weaknesses of the processes, reasons and objectives of the investment, expected benefits of the development program and also new concept of the processes.

3.1 Investment Project Background

The company is a leader in battery case manufacturing that provides to domestic battery manufacturer. In 2007, the company provided battery case to battery industry about 6 million pieces per year with revenues more than 200 million baht. According to economy crisis that had a sign at the beginning of 2008 and increased its impact until 2009, it directly affected to domestic battery industry because domestic battery industry has 3 main product channels which are domestic battery replacement sector, automotive industry and export.

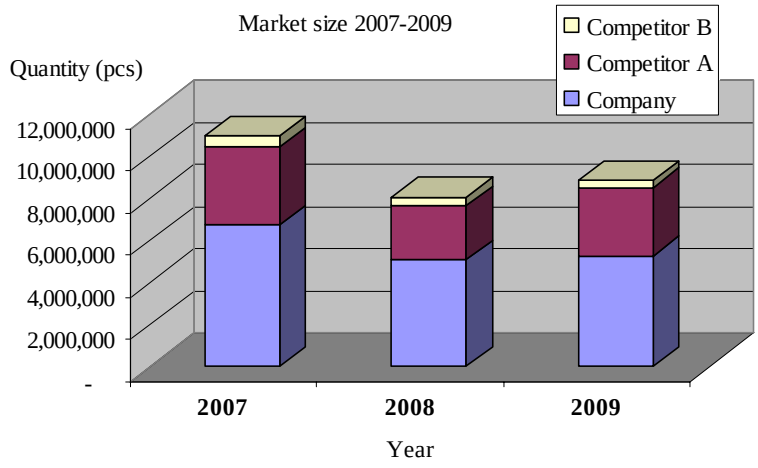

Figure 3.1 Battery case market size year 2007-2009

Source: Company data

As you can see from the figure above, the world economic crisis affected to the battery market and also company's order decreased for 27% in year 2008. The

battery case has characteristic like commodity product that has a low profit margin, mass production needed and battery case price is controlled because battery is a controlled product by the government. Moreover, the cost of producing battery case is rising because the raw material is a petroleum based product which is plastic. And the other significant cost that needs to be improved is energy cost.

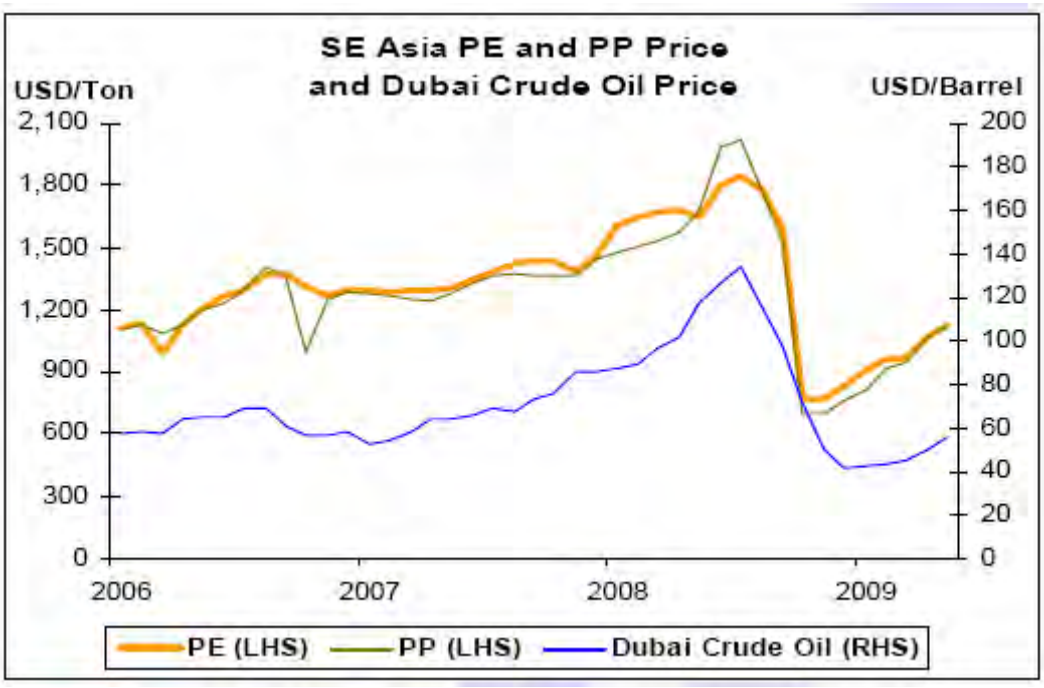

Figure 3.2 Plastic pellet price compare with crude oil price

Source: Plastic polymer report, Industry report. Bangkok bank, 2009

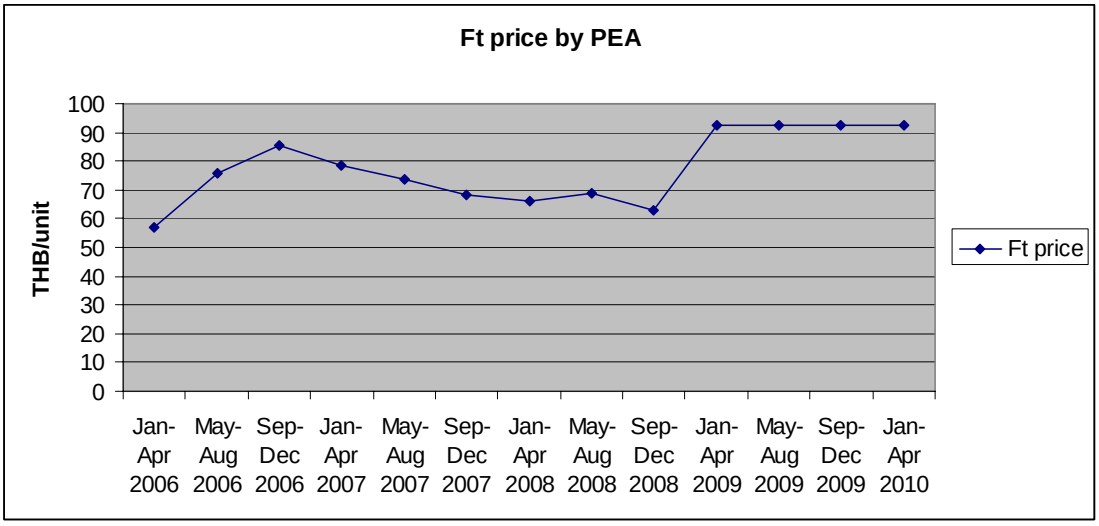

Figure 3.3 Provincial Electricity Authority (PEA) Ft price trend

Source: www.pea.co.th

The figure above show that the price of plastic pellet is related to crude oil price so if the crude oil price rises up, the plastic pellet which is a main material of

battery case will rise up. Moreover the other important cost is energy cost. From figure 3.3, you can see trend of electrical price that Provincial Electricity Authority (PEA) sell to electricity user. Those 2 main costs of production have high probability that will increase continuously so the production cost of battery case will be increased. So the profit margin of the product which has price barrier and increasing cost, will be decreased.

So the company decided to launch development program for batter case production in order to increase profit margin of the product by cost reduction and improve their productivity. In order to get the improvement, the company has to analyze existed production system in order to acknowledge the weakness of the production system and what improvement can be. Not only the profit margin and productivity that company concerned but the company discovered that the utilization of factory space has been using insufficient.

3.2 Reason for Development program

1. Increase marketing capability by using cost reduction program

   Because the battery case characteristic can be described as commodity product which competes on the price, one way to increase marketing capability is to cut the cost in order to gain more margins. The margins that gained from cost reduction program can be used as a discount promotion for their customers.
2. Shorten production lead time

   The other way that can increase marketing capability is delivery time. Short delivery time will satisfy customers and can serve emergency orders that come from the customers. In order to shorten the delivery time, the production time through the processes have to be reduced.
3. Increase flexibility of the production.

   The flexibility of the production provides benefit to the company and their customers. If the development program can increase flexibility of production, the company can provide their customer’s various options of their product. This benefit will increase the marketing capability of the company so the company can gain more market share from their competitor.

4. Utilizing the facility efficiently

   The company discovered that most of factory space has been using for on-process inventory which can not sell as a product and also obstruct the opportunities for the company in order to enlarge the production line even for battery case product or new product production line. Moreover the factory also located in the area that government provides tax exemption privilege. So if the company can reduce the space for on-process product which can not sell for money, and uses the space for production, it will provide the company more benefits.

3.3 The existed battery case production process

At the present, to produce battery case, there are 2 mainly processes that needed which are battery case injection by plastic injection machines which transform plastic liquid into the battery case, and silk screening process which imprint customer's label on side of the battery case by using labors. The flows of battery case production is showed as below

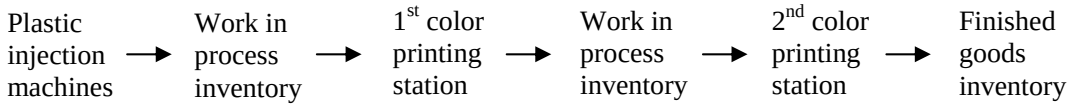

Figure 3.4 Flows of battery case production

The plastic injection process can be breakdown into many processes by looking through actions of the injection machine. The breakdown processes are as followings.

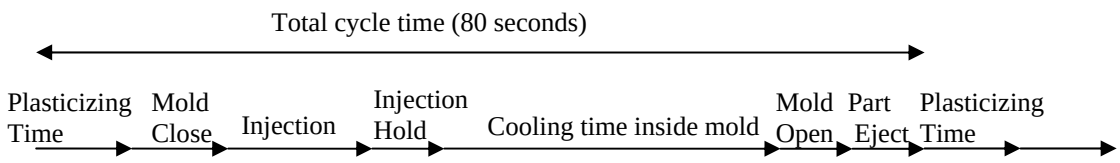

Figure 3.5 Breakdown of Plastic injection process

- Plasticizing time: This process is to transform plastic pellet into liquid
- Mold close: The injection machine will close the mold and preparing for inject plastic liquid into the mold
- Injection: The injection machine injects plastic liquid into the mold.
- Injection Hold: After inject plastic liquid into the mold, the screw drive will maintain the pressure of the plastic liquid inside the mold in order to let the plastic set up and does not shredded.
- Cooling time: This process will cooling the product inside the mold in order to let the product set up completely by inject chilled water into cooling tube inside the mold.
- Mold open: After the product set up completely, the machine will open the mold so 3-axis robot can eject the product out of the mold
- Part Eject: At this process 3-axis robot will bring out the product of the mold and put it on the conveyor which will bring part to operator in order to quality check and cut of the runner.

The plastic injection process spends about 80 seconds per cycle time which can breakdown into 5 processes as show in table 3.1 in order to inject one piece of product at the time

.

Table 3.1 Plastic injection cycle time breakdown

	Description	Amount	Unit
1	**Mold open/close time**	**12.00**	**Seconds**
2	**Injection Time**	**3.40**	**Seconds**
3	**Cooling Time**	**50.00**	**Seconds**
4	**Ejection Time**	**2.00**	**Seconds**
5	**Plasticizing time**	**12.24**	**Seconds**
6	**Total cycle time**	**79.64**	**Seconds**

In plastic injection process, there are 2 significant elements which are plastic injection mold and plastic injection machine (Meiki 450T). The specification of the machine shows in the table 3.2.

Table 3.2 Specification of Existed Plastic Injection Machine

Information	Defender
Brand	**Meiki 450T**
Origin	Japan
Type	Hydraulic Machine
Clamp Force (Ton)	450
Screw Diameter (mm)	65
Injection Capacity (cm3)	995
Injection pressure (kg/cm3)	1640
Injection Flow Rate (g/sec)	250
Plasticizing Rate (kg/hr)	250
Screw L/D ratio	20
Motor Pump Power (Kw)	55
Heater Power (Kw)	21.7
Expected Useful life	≥10 years
Power consumption (Kwh/Kg)	1.2
Average Scrap Rate	1%-2.5%

Figure 3.6: Plastic injection production line

With 80 seconds cycle time, the injection machine consumes a lot of energy so the engineering team decided to redesign the sequence of the processes in order to reduce cycle time by halve. Moreover the engineering team discovered that the injection machine is too big for the battery case process. During injecting battery case, it needed only 200 tons of clamp force, but the existed machine provides 450 Ton of clamp force.

The plastic injection mold is a cold runner mold type which is an old-fashioned design. The existed mold has a low surface area of cooling line so the mold will need chilled water in order to cooling part. The disadvantages of existed mold are:

- Low cooling surface area

  The design of cooling system inside the mold provides low surface of cooling tube and using chilled water in order to transfer heat from the part so the existed mold spent about 60 seconds in order to cool the part.

- Water condensed inside and outside of the mold

  The engineering team discovered that the machine has to be stop frequently because of water condensed inside the mold. This situation occurs because Thailand has a high level of humidity so the operator has to stop the machine and maintenance the mold frequently.

- Cold runner mold provide plastic runner

  This type of the mold will produce excess plastic inject at the bottom of the part because the mold does not have heater system that control the temperature of plastic liquid at the bottom of the part. So when the part has been cooling and set up, the injection machine has to pull the part out in order to break the runner.

Figure 3.7 Plastic runners from production line

After the product injected successfully, the product will come along the conveyor to the operator in order to check the quality of the product and cut off the excess runner. If the product is passed the quality check, the product will be waiting for the silk screen process.

Figure 3.8 Operator check quality of injected part.

Silk screen process is a process that the operator will imprint the artwork of the customer on the side of the case by using screen block and paint the color pigment through screen block. In this process will take a lot of time, because the operator can paint the artwork only one color at the time and have to wait until it dry and then operator can paint other color. If the artwork of the customer has many colors, this process will take a lot of time and spend a lot of space for on-process part.

Figure 3.9 Label screening production line

3.4 Weaknesses of existed battery case program

- High operation and maintenance cost

  The company has set up the standard cost of operation and maintenance for injection and printing process by calculating fix cost, variable cost and direct labor cost in baht per hour as shows in table 3.3 and table 3.4.

Table 3.3 Standard cost of injection process.

Machinery size Ton	Direct labor cost THB	Fix cost THB/hr	Variable cost (THB/hr/person)		Total cost
			Electricity	Others	THB/hr
450	45.42	124.43	73.08	140.69	383.62

Table 3.4 Standard cost of printing process.

Direct labor cost THB	Fix cost THB/hr	Variable cost (THB/hr/person)		Total cost
		Electricity	Others	THB/hr
34.41	15.25	5.58	5.83	61.07

After company set up standard cost for both process, the company can calculates basic cost of battery case production by adding factors such as percentage of good product, utilization rate, production capacity and etc. And then calculate into operation and maintenance cost per unit as show in table 3.5.

Table 3.5 Basic Cost calculation for battery case production

Material	Details	Material	Part weight grams	Loss	Material price (THB/kg) Material	Color	Percentage Material	Color	Use/set pcs	Material cost THB/pcs	Total
	Battery Case	Plastic polymer	850	1.05	49.50		100%		1	44.179	
											44.179
Machinery	**Details**	**M/C size Ton**	**Standard cost THB/Hour**	**% of good product**	**Utilization rate**	**Shot/Hour**	**Cavity pcs**	**Production/Hour**	**Use/set pcs**	**Production cost THB/pcs**	**Total**
	Battery Case	450	383.62	95	80%	45	1	42.75	1	11.217	
											11.217
Printing	**Details**	**Quantity pcs/Hour**	**Standard cost THB/Hour**	**Round**	**No. of labor person**	**Screen**	**Area**	**Description**		**Production cost THB/pcs**	**Total**
	Direct labor cost	300	34.41	1	8					0.9176	
	Machinery cost	300	26.66	1	1					0.0889	
											1.006
Purchase	**Details**	**Material**	**Material price THB/unit**	**Unit/pcs**	**Loss**	**Description**				**Production cost THB/pcs**	**Total**
	Battery Case	Screening pigment	1200	0.001	1.03					1.236	
											1.236
Grand Total											57.638

In Table 3.5 shows production cost calculation for battery case production. The total cost of production is 58.215 Baht per unit which can be divided into material cost and operation and maintenance cost. The standard operation and maintenance cost is 12.346 Baht per unit.

Table 3.6 Actual Operation and Maintenance Cost in 2008

Category	Departments			
	Injection	Maintenance	Label screening	Total
Labor cost	10,349,546.61	884,557.80	9,443,264.00	20,677,368.41
Outsourcing cost	3,880,008.12	94,774.82	4,616,942.62	8,591,725.56
Energy cost	13,285,853.10	1,062,868.25	265,717.06	14,614,438.40
Maintenance cost	4,144,765.70	945,054.47	368,044.99	5,457,865.17
Depreciation	9,392,853.05	9,696,017.52	324,148.79	19,413,019.36
Others cost	2,099,998.67	18,746.74	5,171,980.12	7,290,725.53
Total	43,153,025.24	12,702,019.60	20,190,097.58	76,045,142.43
Production Quantity			5,082,000.00	Piece
Unit cost			14.96	THB

Table 3.7 Actual Operation and Maintenance Cost in 2009

Category	Department			
	Injection	Maintenance	Label screening	Total
Labor cost	11,855,688.90	943,063.13	9,102,865.63	21,901,617.66
Outsourcing cost	4,597,974.37	136,560.00	4,384,103.82	9,118,638.19
Energy cost	13,739,093.48	1,062,868.25	274,781.87	15,076,743.59
Maintenance cost	4,473,012.69	1,639,781.88	320,697.44	6,433,492.01
Depreciation	9,982,789.97	10,277,487.42	912,523.56	21,172,800.95
Others cost	2,784,640.62	16,110.00	5,326,665.31	8,127,415.93
Total	47,433,200.02	14,075,870.68	20,321,637.63	81,830,708.33
Production Quantity			5,286,000.00	Piece
Operation cost per unit			15.48	THB

In table 3.6 and table 3.7 show operation and maintenance cost of batter case production compare to quantity of product selling and calculate into operation and maintenance cost per unit. In year 2008, the company spent 76,045,142.43 Baht in order to deliver 5,082,000 pieces of battery case so the operation and maintenance cost per unit is about 14.96 Baht. In year 2009, the company sold battery case about 5,286,000 pieces which increased from the previous year about 4.01 percent but the company spent 81,830,708.33 Baht for operation and maintenance cost which increased about 7.6 percent and the operation and maintenance cost per unit is about

15.48 baht. From the analysis, the company found that the production cost is more expensive than the basic cost of the company which is about 12.346 baht per piece as shows in table 3.5 and it provides a sign of increasing.

- High rate of Waste and defects

  Waste and defects is an important factor that company concerned in the battery case production. The company has collected data of waste and defects and categorized them into many reasons as shows in table 3.6 and table 3.7 which is higher than the standard rate that company set up at 3%. In 2008, the battery case production produced waste and defects about 283,276.36 kilograms which is about 6.56 percent compared to quantity of selling product. The company lost about 14,022,179.82 baht at plastic pellet price about 49.50 baht per kilograms. The addition cost of product that come from waste and defects is about 3.25 baht per piece. Moreover in year 2009, waste and defects rate increased to 7.31 percent or 386,253.50 kilograms so the company lost about 19,119,548.25 baht. The addition cost of product in year 2009 rose up to 3.62 baht per piece as shows in table 3.8 and table 3.9.

Table 3.8 Quantity of Waste and Defects in year 2008

Unit: kg	Waste and Defects in year 2008										
	Loss in Process	**Return by Customer**	**Reject by QC.**	**M/C Setup**	**Rework**	**Runner**	**Over Stock**	**SCRAP**	**Screw Cleaning**	**Others**	**Total Waste**
JAN	7,351.69	359.02	3,586.23	356.35	1,476.89	2,563.12	-	1,000.00	1,500.00	573.21	**18,766.51**
FEB	8,374.31	582.31	2,305.63	75.36	1,365.25	1,784.65	-	1,000.00	1,500.00	32.49	**17,020.00**
MAR	5,093.27	1,074.82	3,759.69	215.47	2,106.78	2,105.37	-	1,000.00	1,500.00	-	**16,855.40**
APR	4,839.71	578.38	3,257.15	1,043.21	1,529.81	2,206.24	-	1,000.00	1,500.00	-	**15,954.50**
MAY	9,390.37	1,142.69	2,850.43	370.29	2,105.34	3,258.32	-	1,000.00	1,500.00	-	**21,617.44**
JUN	7,593.27	762.34	4,309.51	521.56	1,489.37	2,856.43	-	1,000.00	1,500.00	-	**20,032.48**
JUL	10,939.93	983.03	7,277.45	162.12	2,868.02	4,222.90	2,321.36	1,000.00	1,500.00	6.07	**31,280.88**
AUG	8,562.45	461.79	6,376.46	644.99	3,270.11	2,398.88	6,910.03	1,500.00	1,500.00	14.11	**31,638.82**
SEP	13,584.22	407.97	4,962.90	428.26	1,637.93	2,677.29	228.85	1,000.00	1,500.00	-	**26,427.42**
OCT	15,627.87	1,532.35	4,367.19	1,769.47	1,530.32	6,424.71	-	2,000.00	1,500.00	2,192.61	**36,944.52**
NOV	12,442.09	131.44	4,752.61	481.43	483.04	2,764.83	-	1,500.00	1,500.00	3,866.70	**27,922.14**
DEC	7,650.77	1,287.75	3,532.15	827.46	88.60	2,244.71	179.74	1,500.00	1,500.00	5.07	**18,816.25**
Total	**111,449.95**	**9,303.89**	**51,337.40**	**6,895.97**	**19,951.46**	**35,507.45**	**9,639.98**	**14,500.00**	**18,000.00**	**6,690.26**	**283,276.36**
Quantity of good products (kgs)											**4,319,700**
Percentage of waste and defects compare to good products											**6.56**
Material cost											**49.50**
Loss from waste and defects (THB/Annual)											**14,022,179.82**
Addition production cost from waste and defects (THB/pcs of good product)											**3.25**

Table 3.9 Quantity of Waste and Defects in year 2009

Unit: kg	Waste and Defects in year 2009										
	Loss in Process	**Return by Customer**	**Reject by QC.**	**M/C Setup**	**Rework**	**Runner**	**Over Stock**	**SCRAP**	**Screw Cleaning**	**Others**	**Total Waste**
JAN	6,865.02	402.25	1,777.81	311.76	125.97	1,342.22	-	1,000.00	1,500.00	26.94	13,351.97
FEB	8,787.06	27.56	10,035.91	483.31	14.77	1,269.60	-	1,000.00	1,500.00	-	23,118.21
MAR	11,970.84	807.70	5,244.41	1,002.91	0.23	1,800.23	103.20	1,000.00	2,000.00	-	23,929.52
APR	4,443.08	1,211.94	5,177.03	533.88	1,444.27	1,784.91	-	1,000.00	2,500.00	-	18,095.11
MAY	7,908.65	222.57	2,822.48	655.86	1,308.66	1,567.11	673.86	1,000.00	2,500.00	-	18,659.19
JUN	13,040.19	711.11	4,599.74	722.12	726.52	1,550.63	25.50	3,955.00	3,000.00	2,878.50	31,209.31
JUL	17,734.10	2,797.29	8,133.62	264.98	268.23	1,108.48	228.99	-	4,500.00	8,348.39	43,384.08
AUG	18,434.21	1,344.59	3,452.92	689.60	1,324.55	1,800.16	-	3,000.00	4,000.00	2,922.97	36,969.00
SEP	23,836.88	1,343.39	10,839.40	1,514.85	1,298.51	2,154.26	96.77	2,883.00	3,500.00	2,163.04	49,630.10
OCT	22,969.31	1,197.18	5,756.61	1,066.74	72.54	2,021.89	-	3,000.00	4,500.00	2,080.85	42,665.12
NOV	16,775.11	1,423.53	12,672.51	1,070.31	524.60	3,919.11	-	2,000.00	4,500.00	3,386.36	46,271.53
DEC	18,869.51	103.09	10,649.99	1,571.35	18.73	2,050.62	-	1,000.00	4,000.00	707.07	38,970.36
Total	**171,633.96**	**11,592.20**	**81,162.43**	**9,887.67**	**7,127.58**	**22,369.22**	**1,128.32**	**20,838.00**	**38,000.00**	**22,514.12**	**386,253.50**
Quantity of good products (kgs)											**5,286,000**
Percentage of waste and defects compare to good products											**7.31**
Material cost											**49.50**
Loss from waste and defects (THB/Annual)											**19,119,548.25**
Addition production cost from waste and defects (THB/pcs of good product)											**3.62**

- Long lead time of production

  The existed production system is take long time to produce complete product due to the process have to run in a batch type. After the part have injected by injection machines, parts have to wait in WIP inventory for label printing station. In addition, label printing station consume a lot of time due to number of color in the label.

- Utilize factory space insufficient

  At the present, the existed concept of battery case production, the production line did not provide good management system. After the plastic injection machines inject battery cases, parts will be kept in work in process area before going to printing process. In printing process, if label of customer has many colors, work in process inventory will happen between printing stations because the printing station can print only one color at a time so parts have to be waiting until the color dry. So most of factory spacing spends for keep work in process inventory because there are work in process inventory between every process since injection process through printing process.

3.5 Targets of development program

After the company analyze in existed system, the company found out a lot of problems occurs in the production system, the company decided to launch development program study. Hereby, the targets of development program are

- Reduce injection cycle time to 30 seconds
- Zero wastes and defects due to advanced injection machine and tooling has be applied
- Work-in process inventory reduction

3.6 Control factors related to development target

In order to achieve development targets, there are control factors behind each of development target. To reduce operation and maintenance unit cost by increasing production capacity and reduce number of machines in order to provide capacity that meet market requirements and equal to existed production capacity. The injection

cycle time has to be reduced in order to increase injection capacity per hour per machine. Total injection cycle time can be calculated by following equation.

Total injection cycle time = 2M + T + C + E

Where M = Mold open/close time

T = Injection time

C = Cooling time

E = Ejection time

To reduce injection cycle time, there are control factors that should be concerned. For mold open/close time and ejection time can be reduced to minimum time which provides necessary time due to part removal ability of the robot. Injection time reduction can be done by capability of injection of the injection machine. Cooling time reduction can be done by using mold that has high heat transfer capability the limitation of cooling time reduction are the appearance and dimensions of mold part.

In order to select advance machine that meet to process requirements there are some control factors that should be concerned

- **Clamp force of machine**

  To calculate clamp force for mold part that injected by using polypropylene, the clamping force required is about 2.8 kg/mm^2 of projected area for a wall thickness greater than or equal to 2.3 mm and 3.5 kg/mm^2 is recommend for wall thickness less than 2.3 mm

- **L/D ratio**

  L/D ratio is a proportional of length and diameter of injection screw. This ratio determines the ability of plastic melting ability. For general purpose, L/D ratio is recommended between 16:1 and 24:1. If the L/D ratio is not at recommended level, the plastic might not melt homogeneously.

- **Injection pressure**

  Required injection pressure for polypropylene has ranges from 200 bar to 2,800 bar. Typically injection pressure required is about 1035 bar. So the injection machine has to have injection pressure meet the requirement.

- **Open daylight**

  Open daylight is ability of the machine to open the mold. Open daylight has to held necessary length in order to remove mold part. Required open daylight can be calculated by mold thickness plus 2.5 times of part height.

3.7 New concept of battery case production process

The company aims to improve the battery production process as a whole in order to make it cost-effective with higher profitability. The target of development program is to increase productivity and reduce waste and defect. The productivity improvement program can be obtained through production cycle time reduction. Production cycle time reduction can be separate into 2 steps which are cycle time reduction in injection process and cycle time reduction in screening process.

For the plastic injection processes, the engineering team discovered that the existed process take a long time in order to cooling part inside the mold so they decided to reduce cooling time by halve and cooling the part outside the mold. And the existed machine has a limited function which can not run the plasticizing process parallel with the cooling time process so if this function can be applied the cycle time of injection can be reduced. New concept of the injection sequences shows as followings figure 3.10.

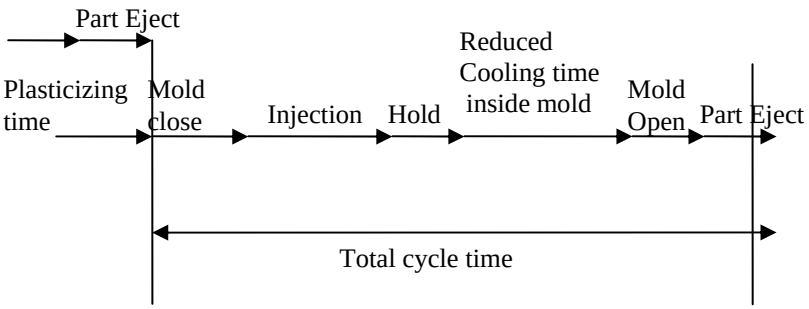

Figure 3.10 New concept of Plastic injection process

- **Plastic injection machine**

  For plastic injection process, the cycle time reduction can be applied by utilizing machine that much superior than existed machine. The machine that can inject part faster and provide special function that can improve the process cycle time. In order to choose injection machine, there are several aspects that have to be concerned especially required clamp force. The

engineering team discovers that required clamp force for part is about 220 Ton. Husky 300T plastic injection machine is selected as challenger machine. The specification of machine shows in table 3.10

Table 3.10 Specification of New Plastic Injection machine

Information	Challenger
Brand	**Husky 300T**
Origin	Canada
Type	Hylectric Machine
Clamp Force (Ton)	300
Screw Diameter (mm)	80
Injection Capacity (cm3)	1759
Injection pressure (kg/cm3)	1550
Injection Flow Rate (g/sec)	2200
Plasticizing Rate (kg/hr)	350
Screw L/D ratio	21.7
Motor Pump Power (kW)	55
Heater Power (kW)	42
Expected Useful life	≥10 years
Power consumption (kWh/kg)	0.8
Average Scrap Rate	0.5%

- **Mold**

  In order to put the part outside to cooling and reduce cooling time by halve, high performance mold is needed. To reduce cooling time, mold have to be redesign in order to provide more surface of cooling line and use a special material, so the mold can transfer heat out of the part faster. The other improvement is hot runner system which helps the robot to bring out part easier and faster.

- **Sizing Fixtures**

  Sizing fixtures is a tool that works as external mold because the part that bring out the part to cooling outside does not successful set up, so sizing fixture is needed in order to protect the part to deform and become to defect and waste.

- **6-axis robot**

  6-axis robot provide quicker take out time compare with existed 3-axis robot and also enable downstream processes as an integrated system so the cycle time can be reduced.

For label screening process, the engineering team decided to substitute manual screening production by automatic screening machine which can be integrated with plastic injection process. The automatic screening machine use heat transfer screening concept in order to screen the customer pattern on the part. This concept provides a lot of benefits compare to manual silk screening by reduce production time, reduce labors, reduce defects which happen along the manual screening process and reduce on-process part inventory. The specification of automatic screening machine shows in table 3.11

Table 3.11 Specification of Automatic screening machine

Model R8BX Specifications	
Electrical system	**220Vac, 60Hz, 20A**
Air	**80 to 100 psi at 3 CFM, moisture-free, 3/8" NPT connections**
Heater	**2.8 kW**
Roller pressure (max)	**980 lbs at 100 psi air pressure**
Roller dimensions	**6" D x 8" L**
Roller slide travel	**Up to 20"**
Roller vertical travel	**Up to 2"**
Head cylinder stroke	**Up to 1"**
Roller climb	**Up to 0.5"**
Working height	**Up to 14"**
Overall dimensions	**70" H x 68" W x 36" D**
Weight (approx.)	**1000 lbs**

To apply the new concept with 5 elements together, the whole cycle time can be reduced significantly. For the injection process, the cycle time can by reduced from 80 seconds to 39 seconds and the screening process which take a lot of time depends on the difficulty of customer pattern can be done by just 10 seconds by using heat transfer screening concept. In addition, cooling outside mold process and label screening process can operates parallel with injection molding process. The finished good can be done equals to injection molding cycle time. For waste reduction, the

engineering team discovered that new design of the injection mold should helps on eliminating quality problem that happens with the existed molds.

- Better cooling system prevents the part from having white marks due to excessive heat before ejection.
- Better balance between partitions reduces the quality problem related to partition imbalance between partition thicknesses.
- Hot runner mold concept eliminates runner wastes

3.8 Comparison of existed production system and new production system

The new production system concept is eliminated injected part quality check station by implementing high efficiency injection machines and molds which are able to inject part efficiently. The WIP inventory between plastic injection stations and silk screening stations have been eliminated by integrated automatic labeling machines by 6-axis robots. The manual silk screening stations which spend many workers and lead time have been combined into one station by implementing automatic labeling machine. By implementing automatic labeling machines, also eliminating WIP inventory between screen stations, the company can obtain factory spaces and reduce workers. The comparison of existed production system and new production system is showed in figure 3.11

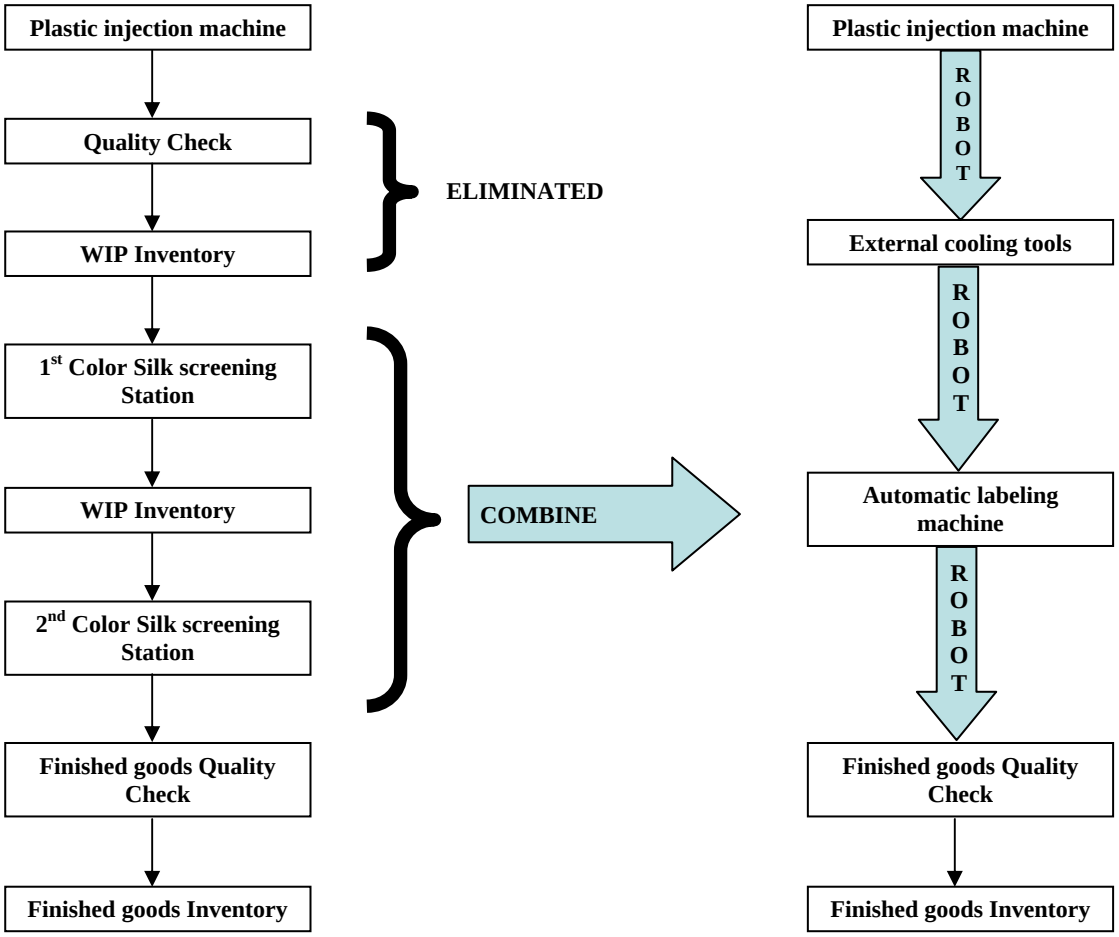

Figure 3.11 Comparison of existed production system and new production system

3.9 Expected benefits of New concept of battery case production process

- Shorten production lead time

  The engineering team wants to shorten production lead time by using lean production instead of batch production. So the new concept of the production system which integrated with automation machines and robots will run as turn key production and the automatic screening system can also reduce production lead time.

- Increase production flexibility

  With the automatic screening machine integrates in the production system can provide flexibility of production because the existed printing station require minimum production quantity in order to prepare screening pigment but the automatic screening machine use screening film which

label pattern is printed on to the film and then use heat transfer technology to transfer the pigment on screening film on the surface of the part. And the screening film also provides opportunity for customer to design the label pattern more creativity.

- Less spacing for production

  Because the new concept of production is combined the injection process and labeling process into a single production cell which the output of this production cell is a completed product so the WIP inventory will be eliminated which used to consume a lot of space in the factory. And with the quantity of the system that reduces by halve by using high performance machine, so the factory obtain some space from that also.

3.10 Proper development target

- **Plastic injection cycle time reduction**

  According to advanced injection machine and tooling that selected to development program, new plastic injection cycle time has calculated. The new plastic injection cycle time as shown in table 3.12 below

Table 3.12 New plastic injection cycle time

	Description	Amount	Unit
1	Mold open/close	12.00	Seconds
2	Injection Time	0.39	Seconds
3	Cooling Time	20.00	Seconds
4	Ejection Time	2.00	Seconds
5	Total cycle time	34.39	Seconds

- **Wastes and defect reduction**

  According to new concept of production, the plastic injection process and label screening process which operates by automatic screening machine has integrated together so the quality control between both processes can not be done. So the quality control department can detects wastes and defects after finished goods come out from the production cell. So the production cell has to be carefully set up in order to prevent wastes and defects. Moreover, wastes and defects still come from machine set up

while changing material because of different customer requirements. The zero waste and defects target is difficult to achieve. Then the proper development target of wastes and defects reduction has set to 2% of quantity of finished goods sold instead.

- **Work-in process inventory reduction**

  According to integrated production cell which operates injection process and label screening together and the output of integrated production cell is finished goods so work-in process inventory which utilizes between injection process and label screening process can be eliminated.

3.11 New Operation and maintenance

To apply new production concept with high performance machines and tools which provide more productivity so the operation and maintenance cost will be reduced. The standard cost for new production concept shows in table 3.13 below.

Table 3.13: Operation and maintenance cost of new production concept.

Details	Material	Part weight	Loss	Material price (THB/kg)		Percentage		Use/set	Material cost	Total	Operation Cost	Basic cost
		grams		Material	Color	Material	Color	pcs	THB/pcs			
Battery Case	Plastic polymer	850	1.05	49.50		100%		1	44.179		1%	
										44.179	0.442	44.621
Details	M/C size	Standard cost	% of good product	Utilization rate	Shot/Hour	Cavity	Production/Hour	Use/set	Production cost	Total	Operation Cost	Basic cost
	Ton	THB/Hour				pcs		pcs	THB/pcs			
Plastic injection	300	282.89	95	80%	105	1	99.75	1	3.545		1%	
Automatic label screening		18.35	95	80%	105	1	99.75	1	0.230		1%	
										3.775	0.038	3.813
Details	Material	Material price	Unit/pcs	Loss	Description				Production cost	Total	Operation Cost	Basic cost
		THB/unit							THB/pcs			
Battery Case	Screening film	1.00	1	1.03					1.03		1%	
										1.030	0.010	1.040
										48.984		49.474

3.12 Investment risk assessment process

After the company found that the existing production system consumed a lot of resources and the engineering department was asked to improve the effectiveness and efficiency of the production system, the engineering department proposed to the company to replace the existing production system with the alternative production system which provides more effectiveness and efficiency. In the past, if the company wanted to make decision on investment, the company will use feasibility study which mainly focusing on financial aspect such as net present value, payback period. According to make decision by using only feasibility study might not be appropriate to large investment. In order to justify that the investment is worthwhile, the replacement analysis concept has been conducted before analyzing feasibility study. The replacement analysis includes 3 tools which are economic life cycle analysis, cost of quality and incremental benefit to cost ratio. After the replacement analysis has been done, then the company have to analyze on feasibility study which focusing on 3 aspects market, technology and financial. And the last step of study, the company has to analyze on investment risk. In each tool that implement in the replacement analysis will provide the support information which will fulfill the decision making. The replacement analysis process is as following

Economic life cycle analysis

The economic life cycle analysis is a tool that using for evaluate expected life of machine or production system by analyzing the total annual worth cost which including the capital recovery which equals to annual worth of initial investment capital and salvage value and the annual worth of estimated annual operation cost in order to estimate number of year which the total annual worth cost is the minimized.

The capital recovery and annual operation cost can be calculated by using equation as follows.

$$Captial\ \text{Recovery} \quad = \quad -P(A/P,i,n) + S(A/F,i,n)$$

$$Annual\ Worth\ of\ \ Annual\ operation\ \text{cost} \quad = \quad -\left[\sum_{n=1}^{n=k} AOC_j(P/F,i,n)\right](A/P,i,k)$$

Where P = Investment capital

S = Market value of assets at the end of the year

i = Minimum attractive rate of return (MARR)

n = Number of study period

The results of this analysis will show the company that the existing production system is already obsolete or the production system can be remained for how many years. And also for the new production system (Challenger), the company will know the economic life of the challenger. According to the number of year of the challenger can be economic operated, not only know when the challenger should be replace but the company can know that the investment is worth or not by comparing the payback period of investment with economic life of the production system.

Cost of Quality analysis

The next aspects that engineering team has to analyze before deciding to replace the existed injection machines by new injection machines are cost of quality. Cost of quality is cost that occurs during production in order to produce finished goods that has good quality in order to satisfy customers.

Cost of quality can be divided in to 4 main aspects which are

1. **Preventive cost**

   Preventive costs are

   - **Quality planning** is a cost that spent for planning quality control for production in order to not delivery defected finished goods to customers
   - **Material inspection** is a cost that spent for inspect quality of raw material before provide to production process
   - **In-process inspection** is a cost that spent for inspect the quality of finished part which come out from injection process and screening process.
   - **Final inspection** is a cost that spent for inspect finished goods which come out production process before delivery to customers
   - **Training cost** is a cost that spent for training workers in order to provide maximum efficiency to their responsibilities
   - **Maintenance cost** is a cost that spent for maintenance machines and tools that use in production in order to work efficiently and protect the unexpected system broke down.

2. **Appraisal cost**
    - **ISO 9000** is a cost that spent in ISO 9000 activities
    - **Quality assurance** is a cost that spent for auditing the production process by internal organization in order to deliver finished good with quality
    - **Quality audit** is a cost that spent for evaluates quality of the production system by external organization and also includes calibrating measuring instruments.
3. **External Failures cost**
    - **Returned products** is a cost that occurs from deliver disqualified products to customers and rejected by customers
    - **Product replacement** is a cost that occurs from replace qualified goods to customers
    - **Revenue lost due to quality** is a loss of opportunity of the company which affected by not to serve customer satisfaction. This figure can achieved from differentiate of market share that losing.
4. **Internal Failures cost**
    - **Defect** is a cost that occurs from parts that not achieves quality
    - **Waste** is a cost that occurs during production such as losses in process, machines set up and etc.
    -

Incremental benefit to cost ratio

The incremental benefit to Cost ratio analysis is a useful tool in order to calculate ratio of incremental benefit and cost which given by new production system compared to existed production system. If the B/C ratio is more than 1.0, so the new production system is appropriate to invest. This calculation is calculated by calculating annual worth of new production system's cash flow and existed production system's cash flow and then calculating the incremental of annual worth net cash flow. The incremental of annual worth net cash flow is represented as incremental benefits. The incremental cost is calculated by calculating annual worth of capital investment of new production system.

Feasibility study

After the investment has been analyzed by using tools above and the result of the analysis support the replacement decision of the company, then the company will conduct feasibility study. The feasibility study focuses on 3 aspects which are marketing, technology and financial. In marketing feasibility study, the study will analyze the status of the market from macro view down to micro view. The market status can be analyzed by collecting information that influenced to the battery market. The market position of the company has to be analyzed in order to know the status of the company in the market. Then the market opportunity and demand can be analyzed by communicating with company's customers in order to know the opportunity and requirement of the market in the future. After market feasibility study has been conducted, then technology study is needed to be analyzed in order to know the requirement of the new production system in many aspects such as labor required and spacing utilize. Technology feasibility study also analyzes the production system in capacity of the system and production lead time in order to know that the production system can serve the market requirement. The last study in feasibility study is financial feasibility study. The financial feasibility study is conducted in order to analyze the investment in several aspects such as net present value, internal rate of return, return on capital employed and payback period. To conduct financial feasibility study, the profit and loss sheet and the cash flow sheet is needed.

Risk management

The risk management program is the last step of investment risk assessment. After the company conducts the replacement analysis by using tools above and the feasibility study support the replacement decision, the company needed to conduct risk management program in order to analyze risk that might affected to the investment. The risk management program has to be run by risk team which members of the team have high experienced in the product. After risk team has been set up, risk management program is conducted by team meeting and discussion. In each meeting, team is asked to discussion and then concludes the idea. By the first meeting, team has been informed the objectives of risk program, generated risk priority number scoring criteria which are severity, occurrence and detection, and asked to think of risk that will affect to investment program internally and externally of the company. In the second meeting, each risk team member presents his ideas individually then summarizes the idea. Then team was asked to scoring all risks by their experience

individually. In the third meeting, the discussion of their scoring of each risk has been conducted and then calculated the risk priority number. After all risks have been calculated into the risk priority number, the team was asked to think of preventive action for critical risk individually and discusses in the forth meeting. The forth meeting is conducted to gather and discuss preventive action for each critical risk and then summarize the preventive action for the development program.

3.13 Conclusion

From the information above, the investment risk assessment of investment can be conducted. The information of existing production system of battery case has been described and the cons of the system have been recognized. The actual of operation and maintenance cost of existing production system has been calculated. The production cost of battery case is more expensive than the standard cost that company set up. Moreover, the existing production system provided a lot of wastes and defects and it shows that the wastes and defect rate rises up steadily. The new production concept and target of development program has been set up. The engineering has selected the alternative production system (Challenger) in order to reduce operation and maintenance cost and also reduce wastes and defects rate. In addition, the challenger also provides other benefits to the company such as flexibility of the production. Before the company decides to launch the investment, the company has to conduct the investment risk assessment study. The investment risk assessment concept has been generated by using tools and techniques which considered in many aspects, not only financial feasibility study, such as economic life cycle, cost of quality, incremental benefit to cost ratio and etc. Those tools and techniques can provide information to support decision making of the company. In the next chapter, the result of investment risk assessment study is showed step by step.

Chapter IV

Investment risk assessment analysis and results

After the investment background has been discussed and the investment risk assessment process has been set up in chapter 3, in this chapter will analyze and evaluate the investment by following the investment risk assessment process. Firstly, the economic life cycle analysis, cost of quality and incremental B/C analysis have been conducted in order to evaluate and compare the existing production system and new production system. After that, the feasibility study is conducted in order to analyze and evaluate new production system. Finally, risk management is conducted in order identify and evaluate risks that might affect to the development program and then set up the preventive action plan.

4.1 Economic life cycle Analysis

At this stage, economic life cycle analysis is conducted by analyzing minimum total annual cost life of existed system in order to know economic life of existed machine left. Then analyze economic life of new injection machine, to find out when the system should be replaced by new system. This analysis is important to the company consideration. Economic life cycle analysis for existed system shows in table 4.1 below.

Table 4.1 Economic life cycle analysis of existed injection machine

Year	Market Value of System	Capital Recovery	Annual expense	Annual Worth of Annual Expense	Total Annual Cost
2009	12,884,901.89				
2010	10,307,921.51	3,865,470.57	34,598,181.00	34,598,181.00	38,463,651.57
2011	8,246,337.21	3,497,330.51	38,407,344.00	36,412,068.14	39,909,398.66
2012	6,597,069.77	3,188,137.36	42,591,928.00	38,279,095.29	41,467,232.65
2013	5,277,655.81	2,927,629.61	47,411,682.00	40,246,901.09	43,174,530.70
2014	4,222,124.65	2,707,431.28	52,678,908.00	42,283,232.50	44,990,663.78
2015	3,377,699.72	2,520,693.76	58,635,744.00	44,402,638.68	46,923,332.44
2016	2,702,159.78	2,361,807.21	65,315,565.00	46,606,976.13	48,968,783.34
2017	2,161,727.82	2,226,167.61	72,766,410.00	48,894,462.12	51,120,629.73
2018	1,729,382.26	2,109,988.67	81,024,328.00	51,260,522.77	53,370,511.44
2019	1,383,505.81	2,010,149.83	90,397,359.00	53,716,179.01	55,726,328.84

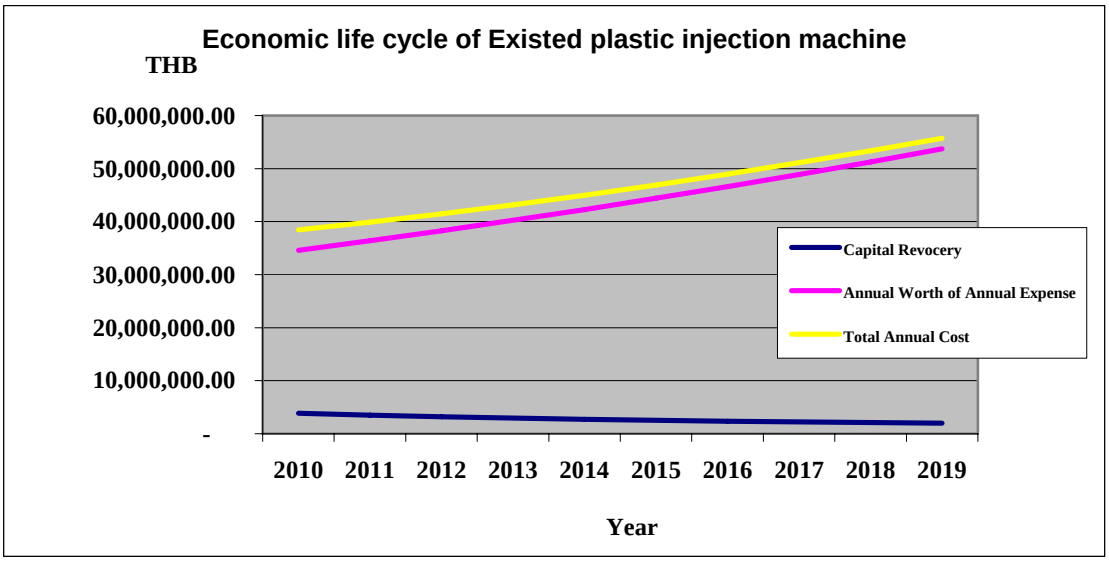

Figure 4.1 Economic life cycle analysis of Existed plastic injection machine

As you can see in figure 4.1, the economic life cycle of existed plastic injection machine has passed. This calculation shows that the existed plastic injection machine needed to be replaced. After economic life cycle of existed production system has been analyzed, the economic life cycle of new system is conducted. The economic life cycle of new injection machine shows in table 4.2 below.

Table 4.2 Economic life cycle analysis of new injection machine

Year	Market Value of System	Capital Recovery	Annual expense	Annual Worth of Annual Cost	Total Annual Cost
2009	108,000,000.00				
2010	97,200,000.00	21,600,000.00	13,384,000.00	13,384,000.00	34,984,000.00
2011	87,480,000.00	20,571,428.57	14,376,213.00	13,856,482.38	34,427,910.95
2012	78,732,000.00	19,642,296.07	15,405,496.00	14,324,462.33	33,966,758.40
2013	70,858,800.00	18,802,844.21	16,461,049.00	14,784,834.37	33,587,678.59
2014	63,772,920.00	18,044,284.29	17,562,431.00	15,239,797.70	33,284,081.99
2015	57,395,628.00	17,358,700.09	18,730,737.00	15,692,249.20	33,050,949.29
2016	51,656,065.20	16,738,960.60	19,939,866.00	16,139,971.37	32,878,931.98
2017	46,490,458.68	16,178,641.41	21,189,817.00	16,581,550.16	32,760,191.57
2018	41,841,412.81	15,671,954.02	22,738,907.00	17,034,981.24	32,706,935.26
2019	37,657,271.53	15,213,682.27	24,338,827.00	17,493,263.93	32,706,946.20
2020	33,891,544.38	14,799,125.12	25,989,577.00	17,951,751.67	32,750,876.79
2021	30,502,389.94	14,424,045.16	27,754,331.00	18,410,152.78	32,834,197.94
2022	27,452,150.95	14,084,622.38	29,574,919.00	18,865,435.47	32,950,057.84
2023	24,706,935.85	13,777,412.46	31,747,352.00	19,325,915.33	33,103,327.79
2024	22,236,242.27	13,499,309.38	33,986,877.00	19,787,351.17	33,286,660.54
2025	20,012,618.04	13,247,511.63	36,304,293.00	20,246,796.67	33,494,308.30
2026	18,011,356.24	13,019,492.00	38,699,601.00	20,701,919.12	33,721,411.12
2027	16,210,220.61	12,812,970.26	41,562,469.00	21,159,395.61	33,972,365.87
2028	14,589,198.55	12,625,888.63	44,521,992.00	21,616,061.21	34,241,949.83
2029	13,130,278.70	12,456,389.74	47,588,971.00	22,069,538.46	34,525,928.20

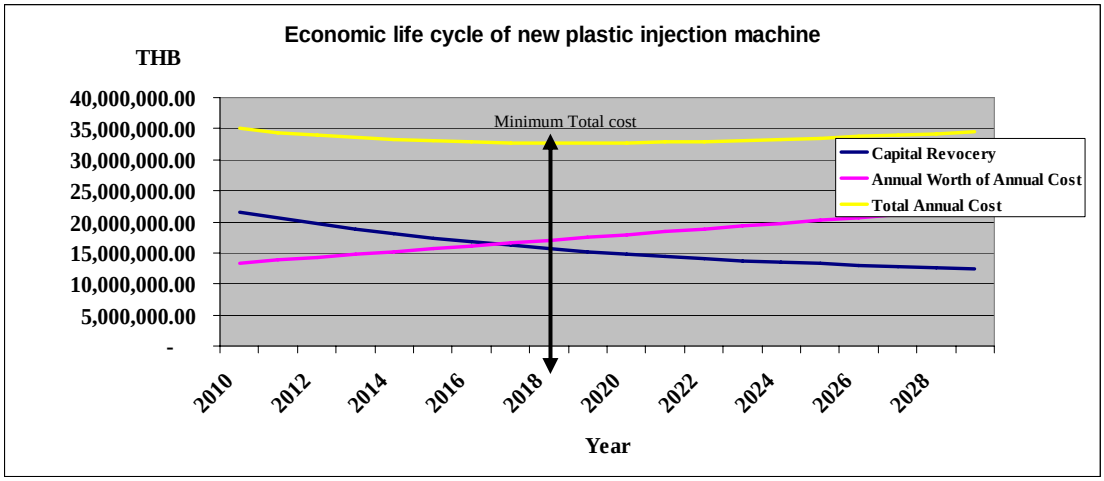

Figure 4.2 Economic life cycle analysis of new plastic injection machine

Economic life cycle of new plastic injection machines, which are Husky 300T, has been analyses in order to analyze expected life of them. The economic life cycle of new plastic injection machines is 9 years which the minimum annual cost of the system at year 9th is about 32,706,935.26 Baht as shows in figure 4.2. After economic life cycle of both machines has been analyzed, the calculation shows that the annual total cost of new machines is less than existed machines. Moreover the economic life cycle of existed plastic injection molding has passed. So the existed machines should be replaced by new system which can be operated for 9 year.

4.2 Cost of Quality analysis

For existed production system, cost of quality can be analyzed by gathering required information from related division such as accounting division, marketing division, production division and etc. The analysis is as following

Table 4.3 Preventive cost for existed production system

	Preventive cost Criteria	Amount	Unit
1	Quality planning	149,194.39	THB
2	Material inspection	84,000.00	THB
3	In-process Inspection	432,000.00	THB
4	Final Inspection	432,000.00	THB
5	Training cost	72,001.33	THB
6	Maintenance cost	4,793,710.13	THB
7	Total Preventive Cost	5,962,905.84	THB

Table 4.4 Appraisal cost for existed production system

	Appraisal cost Criteria	Amount	Unit
1	ISO 9000	20,000.00	THB
2	Quality Assurance	164,640.00	THB
3	Quality audits	795,291.63	THB
4	Total Appraisal Cost	979,931.63	THB

Table 4.5 External failures cost for existed production system

	External Failure cost Criteria	Amount	Unit
1	Returned Product	407,648.01	THB
2	Product Replacement	2,463,355.74	THB
3	Revenue lost due to quality	19,870,690.00	THB
4	Total External Failures Cost	22,741,693.75	THB

Table 4.6 Internal failures for existed production system

	Internal Failures cost Criteria	Amount	Unit
1	Losses in process	11,621,638.32	THB
2	Rejected by QC	5,495,651.36	THB
3	Machine setup	669,511.58	THB
4	Screw cleaning	2,573,047.06	THB
5	Runner	1,514,659.36	THB
6	Overstock	76,400.54	THB
7	Scrap	1,410,977.75	THB
9	Total Internal Failures Cost	23,361,886.00	THB

Table 4.7 Cost of quality for existed production system

	Cost of criteria	Amount	Unit
1	Internal Failures	23,361,886.00	THB
2	External Failures	22,741,693.75	THB
3	Appraisal cost	979,931.63	THB
4	Prevention cost	5,962,905.84	THB
5	Total of Quality cost	53,046,417.22	THB

Cost of quality of new production system is analyzed by referring to cost that spent for existed production system in some aspects such as quality planning, ISO 9000 system and etc. Some cost will be eliminated because of the new concept of production that integrated each processes together by automated robotics, which provides more efficient production, such as in-process inspection cost, revenues lost due to quality, returned and replacement product cost and etc. Some cost will be estimated by referring to information that provided from technology's suppliers such as waste and defects cost, maintenance cost and etc.

Table 4.8 Preventive cost for new production system

	Preventive cost Criteria	Amount	Unit
1	Quality planning	149,194.39	THB
3	Inspection of Material	84,000.00	THB
4	In-process Inspection	-	THB
5	Final Inspection	432,000.00	THB
6	Training cost	100,000.00	THB
7	Maintenance cost	1,080,000.00	THB
8	Total Preventive Cost	1,845,194.39	THB

Table 4.9 Appraisal cost for new production system

	Appraisal cost Criteria	Amount	Unit
1	Quality Assurance	164,640.00	THB
2	Quality audits	1,000,000.00	THB
3	ISO 9000	20,000.00	THB
4	Total Appraisal Cost	1,184,640.00	THB

Table 4.10 External failures cost for new production system

	External Failure cost Criteria	Amount	Unit
1	Returned Product	-	THB
2	Product Replacement	-	THB
3	Revenue lost due to quality	-	THB
4	Total External Failures Cost	-	THB

Table 4.11 Internal failures cost for new production system

	Internal Failures cost Criteria	Amount	Unit
1	Wastes and Defects	6,192,093.60	THB
2	Total Internal Failures Cost	6,192,094.00	THB

Table 4.12 Cost of quality for new production system

	Cost of criteria	Amount	Unit
1	Internal Failures	6,192,094.00	THB
2	External Failures	-	THB
3	Appraisal cost	1,184,640.00	THB
4	Prevention cost	1,845,194.39	THB
5	Total of Quality cost	9,221,928.39	THB

In order to compare cost of quality between existed production system and new production system, the total quality cost has to divided into unit cost because the production capacity of both system are not equally so the comparison is show in the table below

Table 4.13 Comparison of cost of quality

		Capacity (pieces)	Cost of quality (THB)	Cost of quality per unit (THB/pieces)
1	**Existed production system**	**7,227,000.00**	**53,046,417.22**	**7.340032825**
2	**New production system**	**7,358,400.00**	**9,221,928.39**	**1.253251846**

From the comparison of cost of quality shows that new production system spent less resource than existed production system significantly. These figures will support that the replacement of existed production system should be considered.

4.3 Incremental B/C analysis

The incremental benefit/Cost analysis is conducted in order to calculate ratio of incremental benefit and cost which given by new production system compared to existed production system. If the B/C ratio is more than 1.0, so the new production system is appropriate to invest. This calculation is calculated by calculating annual worth of new production system's cash flow and existed production system's cash flow and then calculating the incremental of annual worth net cash flow. The incremental of annual worth net cash flow is represented as incremental benefits. The incremental cost is calculated by calculating annual worth of capital investment of new production system. In order to analyze net cash flow of existed production system, financial hypothesis has to be set up. The financial hypothesis of existed production system is showed in table 4.14 and net cash flow analysis is showed in table 4.15 and table 4.16

Table 4.14 Financial hypothesis of existed production system

Description	Existed production system	Unit
No. of integrated system	15	System
Production capacity per system	1,320	Piece/day
Maximum Production capacity	19,800	Piece/day
Working day	365	days
Production Volume	7,227,000	Pieces/annum
Selling price	70	THB/piece
Material price	49.50	THB/kg
Operation cost	8.56	THB/piece
Maintenance cost	1.76	THB/piece
Marketing management cost	2.00	THB/piece
Waste Cost	3.62	THB/piece
Part weight	850	grams per piece
System Depreciation	6,000,000	THB/annum
Corporate Tax	30%	per annum

Table 4.15 Annual Worth of Existed production system cash flow analysis

Profit/Loss	Year	1	2	3	4	5	6	7	8	9	10
Income											
Revenue		505,890,000	505,890,000	505,890,000	505,890,000	505,890,000	505,890,000	505,890,000	505,890,000	505,890,000	505,890,000
Total income	**-**	**505,890,000**	**505,890,000**	**505,890,000**	**505,890,000**	**505,890,000**	**505,890,000**	**505,890,000**	**505,890,000**	**505,890,000**	**505,890,000**
Production cost											
Material cost		304,076,025	304,076,025	304,076,025	304,076,025	304,076,025	304,076,025	304,076,025	304,076,025	304,076,025	304,076,025
Operation cost		61,858,025	61,858,025	61,858,025	61,858,025	61,858,025	61,858,025	61,858,025	61,858,025	61,858,025	61,858,025
Maintenance cost		12,747,340	12,747,340	12,747,340	12,747,340	12,747,340	12,747,340	12,747,340	12,747,340	12,747,340	12,747,340
Waste cost		26,140,177	26,140,177	26,140,177	26,140,177	26,140,177	26,140,177	26,140,177	26,140,177	26,140,177	26,140,177
System Depreciation		6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
Total of Production cost	**0**	**410,821,567**	**410,821,567**	**410,821,567**	**410,821,567**	**410,821,567**	**410,821,567**	**410,821,567**	**410,821,567**	**410,821,567**	**410,821,567**
Initial profit		**95,068,433**	**95,068,433**	**95,068,433**	**95,068,433**	**95,068,433**	**95,068,433**	**95,068,433**	**95,068,433**	**95,068,433**	**95,068,433**
Marketing management cost											
Marketing management cost		14,454,000	14,454,000	14,454,000	14,454,000	14,454,000	14,454,000	14,454,000	14,454,000	14,454,000	14,454,000
Total of Marketing management cost	**0**	**14,454,000**	**14,454,000**	**14,454,000**	**14,454,000**	**14,454,000**	**14,454,000**	**14,454,000**	**14,454,000**	**14,454,000**	**14,454,000**
Gross profit (EBIT)	**0**	**80,614,433**	**80,614,433**	**80,614,433**	**80,614,433**	**80,614,433**	**80,614,433**	**80,614,433**	**80,614,433**	**80,614,433**	**80,614,433**
Tax		24,184,330	24,184,330	24,184,330	24,184,330	24,184,330	24,184,330	24,184,330	24,184,330	24,184,330	24,184,330
Net profit		**56,430,103**	**56,430,103**	**56,430,103**	**56,430,103**	**56,430,103**	**56,430,103**	**56,430,103**	**56,430,103**	**56,430,103**	**56,430,103**
EBITDA	**0**	**86,614,433**	**86,614,433**	**86,614,433**	**86,614,433**	**86,614,433**	**86,614,433**	**86,614,433**	**86,614,433**	**86,614,433**	**86,614,433**

Table 4.16 Annual Worth of Existed production system cash flow analysis (continued)

Cash Flow analysis	Year	1	2	3	4	5	6	7	8	9	10
Operation cash flow:											
Net profit	-	56,430,103.21	56,430,103.21	56,430,103.21	56,430,103.21	56,430,103.21	56,430,103.21	56,430,103.21	56,430,103.21	56,430,103.21	56,430,103.21
plus: depreciation	-	6,000,000.00	6,000,000.00	6,000,000.00	6,000,000.00	6,000,000.00	6,000,000.00	6,000,000.00	6,000,000.00	6,000,000.00	6,000,000.00
Net operation cash flow	-	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21
Investment cash flow:											
Fix assets investment	-	-	-	-	-	-	-	-	-	-	-
Net investment cash flow	-	-	-	-	-	-	-	-	-	-	-
Funding raising cash flow:											
Long term loan (debt payment)	-	-	-	-	-	-	-	-	-	-	-
Selling existed system	-	-	-	-	-	-	-	-	-	-	-
Net Funding raising cash flow	-	-	-	-	-	-	-	-	-	-	-
Net cash flow	-	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21	62,430,103.21
NPV	383,605,958.59										
AW of Existed production system net cash flow	45,058,211.96										

After the calculation of annual worth of existed production system net cash flow was done, the annual worth of new production system net cash flow is calculated. The financial hypothesis of new production system has set up as showed in table 4.17. The annual worth of new production system net cash flow calculation is showed in table 4.18, 4.19, 4.20 and 4.21.

Table 4.17 Financial hypothesis of new production system

Description	New Production system	Unit
No. of integrated system	8	System
Production capacity per system	2,520	Piece/day
Overall Production capacity	20,160	Piece/day
Working day	365	days
Production Volume	7,358,400	Pieces/annum
Selling price	70	THB/piece
Operation cost	3.81	THB/piece
Maintenance cost	1.5%	of initial investment/annum
Marketing management cost	2.00	THB/piece
Waste estimation	2.0%	of production/annum
Part weight	850	grams per piece
Material price	49.50	THB/kg
Initial investment	108,000,000	THB
Long-term loan	108,000,000	THB
Interest rate (MLR), kd	6%	per annum
Loan duration	5	Year
Tax provision		
- Year 1-3 receives Tax exemption from BOI	0%	per annum
- From year 4 onward	30%	per annum
Depreciation (linear projection)	20	Year
Discounted rate (MARR)	10%	

Table 4.18 Annual Worth of New production system cash flow analysis

Profit/Loss	Year	1	2	3	4	5	6	7	8	9	10
Income											
Revenue		515,088,000	515,088,000	515,088,000	515,088,000	515,088,000	515,088,000	515,088,000	515,088,000	515,088,000	515,088,000
Total income	**-**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**
Production cost											
Material cost		309,604,680	309,604,680	309,604,680	309,604,680	309,604,680	309,604,680	309,604,680	309,604,680	309,604,680	309,604,680
Operation cost		28,055,274	25,209,485	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197
Maintenance cost		1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000
Waste cost		7,284,816	7,284,816	7,284,816	7,284,816	7,284,816	7,284,816	7,284,816	7,284,816	7,284,816	7,284,816
System Depreciation		5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000
Total of Production cost	**0**	**351,964,770**	**349,118,981**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**
Initial profit		**163,123,230**	**165,969,019**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**
Marketing management cost											
Marketing management cost		14,716,800	14,716,800	14,716,800	14,716,800	14,716,800	14,716,800	14,716,800	14,716,800	14,716,800	14,716,800
Total of Marketing management cost	**0**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**
Gross profit (EBIT)	**0**	**148,406,430**	**151,252,219**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**
Interest		5,832,000	4,536,000	3,240,000	1,944,000	648,000	0	0	0	0	0
Profit before Tax	0	142,574,430	146,716,219	146,235,507	147,531,507	148,827,507	149,475,507	149,475,507	149,475,507	149,475,507	149,475,507
Tax		0	0	0	44,259,452	44,648,252	44,842,652	44,842,652	44,842,652	44,842,652	44,842,652
Net profit	**0**	**142,574,430**	**146,716,219**	**146,235,507**	**103,272,055**	**104,179,255**	**104,632,855**	**104,632,855**	**104,632,855**	**104,632,855**	**104,632,855**
EBITDA	**0**	**153,806,430**	**156,652,219**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**

Table 4.19 Annual Worth of New production system cash flow analysis (continued)

Profit/Loss	Year	11	12	13	14	15	16	17	18	19	20
Income											
Revenue		515,088,000	515,088,000	515,088,000	515,088,000	515,088,000	515,088,000	515,088,000	515,088,000	515,088,000	515,088,000
Total income	**-**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**	**515,088,000**
Production cost											
Material cost		309,604,680	309,604,680	309,604,680	309,604,680	309,604,680	309,604,680	309,604,680	309,604,680	309,604,680	309,604,680
Operation cost		26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197
Maintenance cost		1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000
Waste cost		7,284,816	7,284,816	7,284,816	7,284,816	7,284,816	7,284,816	7,284,816	7,284,816	7,284,816	7,284,816
System Depreciation		5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000
Total of Production cost	**0**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**	**350,895,693**
Initial profit		**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**	**164,192,307**
Marketing management cost											
Marketing management cost		14,716,800	14,716,800	14,716,800	14,716,800	14,716,800	14,716,800	14,716,800	14,716,800	14,716,800	14,716,800
Total of Marketing management cost	**0**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**	**14,716,800**
Gross profit (EBIT)	**0**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**	**149,475,507**
Interest		0	0	0	0	0	0	0	0	0	0
Profit before Tax	0	149,475,507	149,475,507	149,475,507	149,475,507	149,475,507	149,475,507	149,475,507	149,475,507	149,475,507	149,475,507
Tax		44,842,652	44,842,652	44,842,652	44,842,652	44,842,652	44,842,652	44,842,652	44,842,652	44,842,652	44,842,652
Net profit	**0**	**104,632,855**	**104,632,855**	**104,632,855**	**104,632,855**	**104,632,855**	**104,632,855**	**104,632,855**	**104,632,855**	**104,632,855**	**104,632,855**
EBITDA	**0**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**	**154,875,507**

Table 4.20 Annual Worth of New production system cash flow analysis (continued)

Cash Flow analysis	Year	1	2	3	4	5	6	7	8	9	10
Operation cash flow:											
Net profit	(108,000,000.00)	153,806,430.06	156,652,219.43	154,875,507.42	154,875,507.42	154,875,507.42	154,875,507.42	154,875,507.42	154,875,507.42	154,875,507.42	154,875,507.42
plus: depreciation	-	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00
Net operation cash flow	(108,000,000.00)	159,206,430.06	162,052,219.43	160,275,507.42	160,275,507.42	160,275,507.42	160,275,507.42	160,275,507.42	160,275,507.42	160,275,507.42	160,275,507.42
Investment cash flow:											
Fix assets investment	(108,000,000.00)	-	-	-	-	-	-	-	-	-	-
Net investment cash flow	(108,000,000.00)	-	-	-	-	-	-	-	-	-	-
Funding raising cash flow:											
Long term loan (debt payment)	108,000,000.00	(21,600,000.00)	(21,600,000.00)	(21,600,000.00)	(21,600,000.00)	(21,600,000.00)	-	-	-	-	-
Selling existed system		12,884,901.89	-	-	-	-	-	-	-	-	-
Net Funding raising cash flow	108,000,000.00	(8,715,098.11)	(21,600,000.00)	(21,600,000.00)	(21,600,000.00)	(21,600,000.00)	-	-	-	-	-
Net cash flow	(108,000,000.00)	150,491,331.95	140,452,219.43	138,675,507.42	138,675,507.42	138,675,507.42	160,275,507.42	160,275,507.42	160,275,507.42	160,275,507.42	160,275,507.42

NPV	**807,152,632.21**
Annual Worth of Existed production system net cash flow	**94,807,845.31**

Table 4.21 Annual Worth of New production system cash flow analysis (continued)

Cash Flow analysis	11	12	13	14	15	16	17	18	19	20
Operation cash flow:										
Net profit	**154,875,507.42**	**154,875,507.42**	**154,875,507.42**	**154,875,507.42**	**154,875,507.42**	**154,875,507.42**	**154,875,507.42**	**154,875,507.42**	**154,875,507.42**	**154,875,507.42**
plus: depreciation	**5,400,000.00**	**5,400,000.00**	**5,400,000.00**	**5,400,000.00**	**5,400,000.00**	**5,400,000.00**	**5,400,000.00**	**5,400,000.00**	**5,400,000.00**	**5,400,000.00**
Net operation cash flow	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**
Investment cash flow:										
Fix assets investment	-	-	-	-	-	-	-	-	-	-
Net investment cash flow	-	-	-	-	-	-	-	-	-	-
Funding raising cash flow:										
Long term loan (debt payment)	-	-	-	-	-	-	-	-	-	-
Selling existed system	-	-	-	-	-	-	-	-	-	-
Net Funding raising cash flow	-	-	-	-	-	-	-	-	-	-
Net cash flow	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**	**160,275,507.42**

Table 4.22 Incremental B/C ratio analysis

Description	Existed production system	New production system	Unit
Initial investment	**12,884,901.89**	**108,000,000.00**	**THB**
Annual worth net cash flow	**45,058,211.96**	**94,807,845.31**	**THB**
Annual worth of total cost	**2,096,958.45**	**12,685,639.48**	**THB**
Incremental cost		**10,588,681.03**	**THB**
Incremental benefit		**49,749,633.36**	**THB**
Incremental B/C ratio		**4.70**	

In table 4.22, incremental B/C ratio calculation is showed. The incremental benefit is calculated by differentiation between annual worth of new production system cash flow and annual worth of existed production system. Incremental cost is calculated by differentiation between annual worth of total cost of new production system and annual worth of existed production system. The incremental B/C ratio is calculated by dividing incremental benefit by incremental cost. The calculation shows that the incremental B/C ratio equals to 4.70 which more than 1.0. So benefit that achieves from new production system is acceptable.

4.4 Market feasibility

The market feasibility is conducted to analyze in 4 main aspects which are market status, market position of the company, market opportunity and market demand in order to evaluate the status of the market before launches the investment program.

4.4.1. Market status

The market status can be evaluated by gathering market information that related to the product. Battery market can be divided into 3 segments which are replacement market, automotive industry and export. The replacement market information can be obtained by looking at the trend of car registration.

Table 4.23 Statistics of car registration in Thailand

Source: Department of Land Transport

Year	Total	4 wheels car	Transportation car	Truck	Others
2004	7,418,139	6,377,515	106,903	684,780	248,941
2005	8,022,559	6,935,944	107,712	716,276	262,627
2006	9,157,030	7,881,836	114,188	718,562	442,444
2007	9,656,520	8,313,336	120,742	747,735	474,707
2008	10,152,949	8,740,576	125,397	771,554	515,422
2009	10,635,270	9,159,128	127,553	791,414	557,175

Looking to number of car registration in Thailand, the number of car registration was increasing continuously. Since 2007 the number of car registration is about 5% growth each year. This trend shows that the battery replacement market has an opportunity to grow. According to information obtained from battery manufacturers which are company's customers, the replacement sector is about 40-50% of the battery market. The other important market for battery is automotive industry. This segment holds about 30-40% of the battery market. The automotive industry trend can assist the company to forecast the trend of the market.

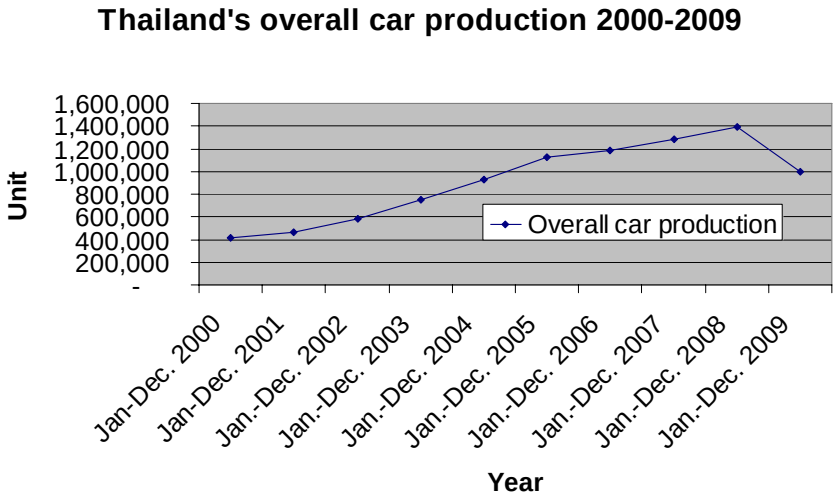

Figure 4.3 Thailand's overall car production 2000-2009

Source: The Federation of Thai Industries

From the figure above, the automotive industry has been growing continuously until 2008 when the world economic crisis occurred. The world economic situation affects significantly to automotive industry. The overall production decreased by 28.3%, affecting directly to battery market. Given those trends above, the company understands the status of the battery market in the macro views. To assure the market status of battery case, the evaluation of the battery case market can be accomplished by confirmation with company's customers and referencing to overall capacity.

Table 4.24 Overall production of battery case in 2007-2009

Year	Overall production	Unit
2007	11,011,000.00	piece
2008	8,073,000.00	piece
2009	8,848,000.00	piece

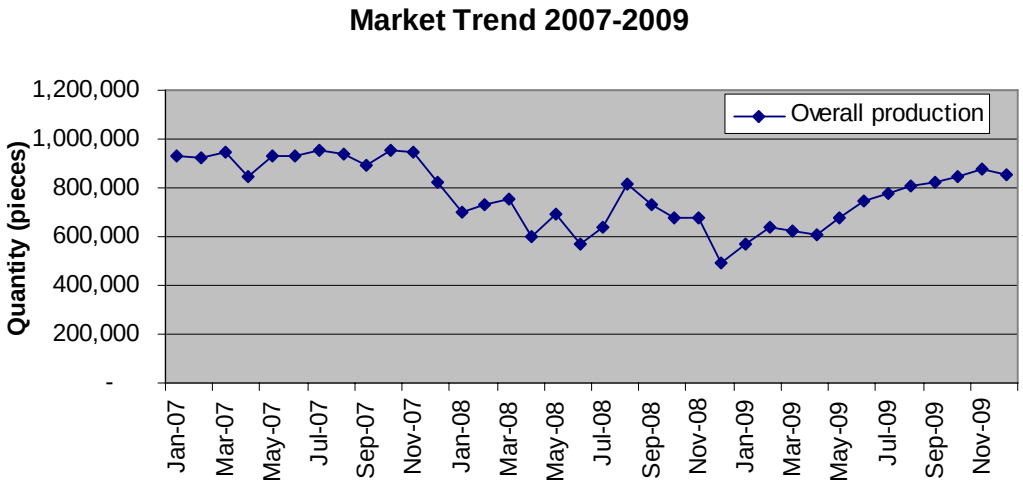

Figure 4.4 Battery case market trend 2007-2009

In table 4.24 shows the overall production per year from 2007-2009. The battery case production was reduced in year 2008 for 26.68% and rebound in 2009 with 9.65 growth. In figure 4.4 shows the overall battery cases production which contribute into battery manufacturing industry in monthly basis. The trend of monthly production appears to be increased continuously since March 2009.

4.4.2. Market position of the company

In figure 4.5 shows the market share of the company in year 2007-2009. The market share of the company is about 61% in year 2007 and increased to 63% in 2008. In year 2009 the market share of the company decreases to 59% due to more competition in the market.

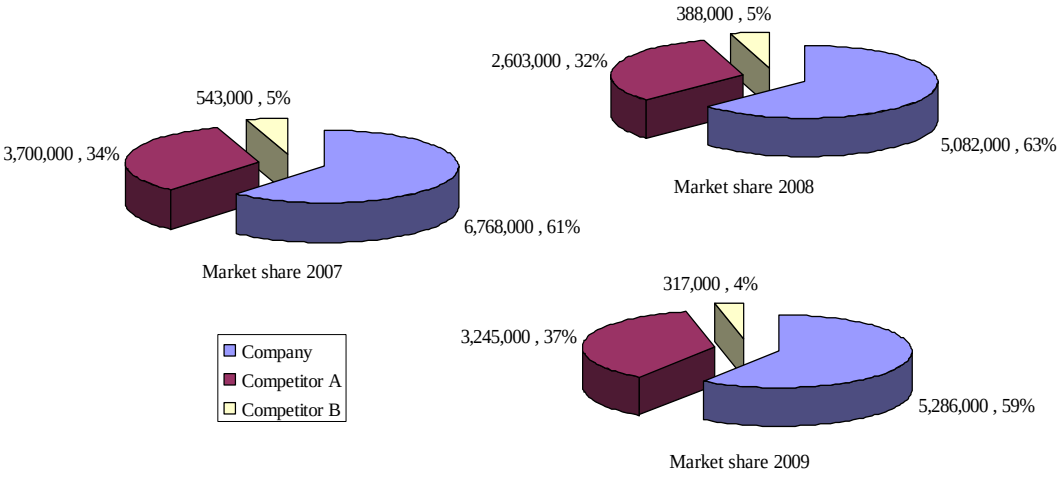

Figure 4.5: Market position of the company

4.4.3. Market opportunity

The market opportunity can be obtained by looking into the forecast of battery market. The forecasting of battery market can be obtained by communicating with battery manufacturers. In table 4.25 shows the forecast of battery production of company's customer form 2010-2012. The forecast shows that the overall production in 2010 will increase to 10 million pieces and continue to increase subsequently.

Table 4.25 Forecasting of battery industry

Battery Capacity & Forecast			
	2010	**2011**	**2012**
Customer A	3,600,000	3,800,000	4,000,000
Customer B	2,600,000	2,650,000	3,000,000
Customer C	1,500,000	1,500,000	1,560,000
Customer D	540,000	660,000	720,000
Customer E	720,000	760,000	800,000
Customer F	1,320,000	1,400,000	1,450,000
Total	**10,280,000**	**10,770,000**	**11,530,000**

With the average of market share from 2007-2009 at 61.39%, the company can forecast selling volume of the company in 2010-2012 as you can see in table 4.26. With the 7 million pieces capacity in year 2012, the production capacity will reach the maximum capacity of the existed machine.

Table 4.26 Forecasting of company sale volume

Battery Case Capacity & Forecast			
	2010	**2011**	**2012**
Customer A	2,210,000	2,333,000	2,455,000
Customer B	1,596,000	1,627,000	1,842,000
Customer C	921,000	921,000	958,000
Customer D	331,000	405,000	442,000
Customer E	442,000	467,000	491,000
Customer F	810,000	859,000	890,000
Total	**6,310,000**	**6,612,000**	**7,078,000**

4.4.4. Market demand

To meet the market needs, the company has to understand the battery case market and the downstream market which is battery market. Battery market consists of 3 main market which are replacement market, automotive market and export. In order to compete in those markets, battery manufacturers have to

compete among their rivals by price war. The price war situation of battery market makes the manufacturers to reduce production cost in order to improve their competitiveness. One way to reduce production cost is to reduce the material cost. Battery case is one material in battery production. In order to gain competitive advantage, price of the battery case has to be competitive in the market.

4.4.5. Market feasibility summary

Even though the status of related section show different results which there are steady growth on the number of registered car which let the company know that there is an opportunity available in battery replacement market but in the automotive industry, the overall car production in Thailand shows that the industry has recession in 2009. But the production capacity in the next 3 year information which collects from battery manufacturer shows that the battery market will be rebounded after recessed for 2 years so there are opportunities in the market. Even the company is a largest player in battery case market in order to maintain and grow in the market, the company has to reduce their production cost in order to gain more profit margins or possibly provide interesting promotion to their customers.

4.5 Technical Feasibility

Technical feasibility study is conducted in order to analyze whether the integrated system can provide the benefits to the production system as expected and meet to market requirement. In this feasibility study will contain 4 aspects which are production capacity, production lead time, labor required, and spacing utilizes.

4.5.1. Production capacity

The expected capacity of the production has to cover the market demand as shown in market feasibility section. The existed system operates by using 15 plastic injection machines with 6 stations of label screening which can provide maximum production capacity about 7,227,000 pieces per annum. The integrated system which operates by high performance plastic injection machine and automatic label screening machine can provide capacity about 919,800 pieces per

annum per set. In order to cover the market demand, the company will need about 8 sets of integrated system so the new integrated system will provide maximum production capacity about 7,358,400 pieces per annum.

4.5.2. Production lead time

The existed production system required long lead time of production because of limitation of label screening station which requires minimum quantity in order to set up the station and require time in order to wait first color to dry before screen the other color so the production has characteristic like batch production which take a long time while the new integrated system operates as lean production system. With 5 elements which are high performance plastic injection machines, high performance molds, sizing fixtures for outside cooling, 6-axis robots and automatic label screening machines, the finished product will required only 45 seconds per piece maximum and best production time is 35 seconds.

4.5.3. Labor required

The existed production system required a lot of labor in order to operate the production. There are 15 operators per shift to operate the plastic injection machines and 90 operators per shift to operate the label screening stations. The total workers for existed production system are 315 operators in order to operate full production capacity. This figure is excluding staff from other department such as engineering, quality control, cargo and etc. The new integrated system can reduces operator for operation with significant number because the output of the integrated system is finished products so the workers for label screening stations will be eliminated. The total operators required for new integrated system are 8 operators per shift in order to operate full production capacity. This aspects will reduce operation cost that come form direct labor cost.

4.5.4. Spacing utilizes

The existed production system spends a lot of spacing in order to operate the production. The spacing utilize for plastic machine is about 24 square meters

per machine and 9 square meters per label screening station. The total spacing for operating the production is about 414 square meters which excluding work-in-process inventory that occurs between injection station and label screening station, and parts that screen first color and wait for screening second color. Due to the new integrated system output is finished goods so the space that utilizing for work in process inventory will be eliminated. The total spacing that required for the integrated system is about 264 square meters.

4.5.5. Technology feasibility summary

The new production system which integrated injection process and labeling together by using automated robotics will consume less resource in many aspects such as labor cost, energy cost and etc. For labor cost, the new production system spent less than existed system significantly by using automated robotic instead. For energy cost, even the new system has to add labeling machine but new injection machines are smaller and fewer than existed injection machine. In the addition, the new concept of machines and tools provide less wastes and defects.

4.6 Financial Feasibility

At this step the financial feasibility is conducted in order to analyze financial aspects of the investment. In order to calculate payback period, ROCE, Net present value and internal rate of return by using profit and loss sheets and cash flow analysis sheets.

The factory is located at Samut Prakarn province which is one of promotion area of Thailand Board of Investment (BOI) which provides financial incentive to investment project. According to BOI announcement (BOI, 2000), the investment project that located in promotion area will receives corporate tax exemption for 3 years. Moreover BOI offers 50% import duty reduction for machines that have import duty more than 10%. The last offer is import duty exemption for material that required for production but the product has to be exported. So the company can not receive the last offer of the incentive because the product is selling to domestic customers only.

The main hypothesis and financial hypothesis for feasibility study can be described as table 4.27 and table 4.28.

Table 4.27 Main hypothesis for feasibility study

Main Hypothesis		
No. of integrated system	8	System
Production capacity per system	2,520	Piece/day
Overall Production capacity	20,160	Piece/day
Working day	365	days
Production Volume	7,358,400	Pieces/annum
Selling price	70	THB/piece
Operation cost	3.813	THB/piece
Maintenance cost	1.5%	of initial investment/annum
Marketing management cost	2.00	THB/piece
Waste estimation	2.0%	of production/annum
Part weight	850	grams per piece
Material price	49.50	THB/kg
Existed system value	12,884,902	THB

Table 4.28 Financial hypothesis for feasibility study

Financial Hypothesis			
Initial investment per system		13,500,000	THB/system
Overall investment		108,000,000	THB
Long-term loan		108,000,000	THB
Interest rate (MLR)		6%	per annum
Loan duration		5	Year
Tax provision			
- Year 1-3 receives Tax exemption from BOI		0%	0%
- From year 4 onward		30%	per annum
Depreciation (linear projection)		20	Year
Discounted rate (MARR)		10%	

After the financial hypothesis and required information has been setup, the profit and loss sheet and cash flow analysis sheet will be conducted in order to calculate payback period, ROCE, Net present value and internal rate of return. The profit and loss sheet shows in table 4.29 and the cash flow analysis sheet shows in table 4.30

Table 4.29 Profit and loss sheet of investment program

Profit/Loss	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Income										
Revenue	441,700,000	462,840,000	495,460,000	495,460,000	495,460,000	495,460,000	495,460,000	495,460,000	495,460,000	495,460,000
Total income	**441,700,000**	**462,840,000**	**495,460,000**	**495,460,000**	**495,460,000**	**495,460,000**	**495,460,000**	**495,460,000**	**495,460,000**	**495,460,000**
Production cost										
Material cost	265,493,250	278,199,900	297,806,850	297,806,850	297,806,850	297,806,850	297,806,850	297,806,850	297,806,850	297,806,850
Operation cost	24,058,053	25,209,485	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197	26,986,197
Maintenance cost	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000	1,620,000
Waste cost	5,309,865	5,563,998	5,956,137	5,956,137	5,956,137	5,956,137	5,956,137	5,956,137	5,956,137	5,956,137
System Depreciation	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000	5,400,000
Total of Production cost	**301,881,168**	**315,993,383**	**337,769,184**	**337,769,184**	**337,769,184**	**337,769,184**	**337,769,184**	**337,769,184**	**337,769,184**	**337,769,184**
Initial profit	**139,818,832**	**146,846,617**	**157,690,816**	**157,690,816**	**157,690,816**	**157,690,816**	**157,690,816**	**157,690,816**	**157,690,816**	**157,690,816**
Marketing management cost										
Marketing management cost	12,620,000	13,224,000	14,156,000	14,156,000	14,156,000	14,156,000	14,156,000	14,156,000	14,156,000	14,156,000
Total of Marketing management cost	**12,620,000**	**13,224,000**	**14,156,000**	**14,156,000**	**14,156,000**	**14,156,000**	**14,156,000**	**14,156,000**	**14,156,000**	**14,156,000**
Gross profit (EBIT)	**127,198,832**	**133,622,617**	**143,534,816**	**143,534,816**	**143,534,816**	**143,534,816**	**143,534,816**	**143,534,816**	**143,534,816**	**143,534,816**
Interest	5,832,000	4,536,000	3,240,000	1,944,000	648,000	0	0	0	0	0
Profit before Tax	121,366,832	129,086,617	140,294,816	141,590,816	142,886,816	143,534,816	143,534,816	143,534,816	143,534,816	143,534,816
Tax	0	0	0	42,477,245	42,866,045	43,060,445	43,060,445	43,060,445	43,060,445	43,060,445
Net profit	**121,366,832**	**129,086,617**	**140,294,816**	**99,113,571**	**100,020,771**	**100,474,371**	**100,474,371**	**100,474,371**	**100,474,371**	**100,474,371**
EBITDA	**132,598,832**	**139,022,617**	**148,934,816**	**148,934,816**	**148,934,816**	**148,934,816**	**148,934,816**	**148,934,816**	**148,934,816**	**148,934,816**

Table 4.30 Cash flow sheet of investment program

Cash Flow analysis	Investment	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Operation cash flow:											
Net profit	(108,000,000.00)	132,598,831.82	139,022,617.43	148,934,816.42	148,934,816.42	148,934,816.42	148,934,816.42	148,934,816.42	148,934,816.42	148,934,816.42	148,934,816.42
plus: depreciation	-	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00	5,400,000.00
Net operation cash flow	(108,000,000.00)	137,998,831.82	144,422,617.43	154,334,816.42	154,334,816.42	154,334,816.42	154,334,816.42	154,334,816.42	154,334,816.42	154,334,816.42	154,334,816.42
Investment cash flow:											
Fix assets investment	(108,000,000.00)	-	-	-	-	-	-	-	-	-	-
Net investment cash flow	(108,000,000.00)	-	-	-	-	-	-	-	-	-	-
Funding raising cash flow:											
Long term loan (debt payment)	108,000,000.00	(21,600,000.00)	(21,600,000.00)	(21,600,000.00)	(21,600,000.00)	(21,600,000.00)	-	-	-	-	-
Selling existed system		12,884,901.89	-	-	-	-	-	-	-	-	-
Net Funding raising cash flow	108,000,000.00	(8,715,098.11)	(21,600,000.00)	(21,600,000.00)	(21,600,000.00)	(21,600,000.00)	-	-	-	-	-
Net cash flow	(108,000,000.00)	129,283,733.71	122,822,617.43	132,734,816.42	132,734,816.42	132,734,816.42	154,334,816.42	154,334,816.42	154,334,816.42	154,334,816.42	154,334,816.42

Table 4.31 Financial feasibility summarization

Financial feasibility summarization			
Initial investment		**108,000,000.00**	**THB**
Net present Value	**NPV**	**747,110,394.10**	**THB**
Internal rate of return	**IRR**	**119.28%**	
Return on Capital employed	**ROCE**	**2633.75%**	
Pay back period	**Payback**	**10**	**months**

Financial feasibility summary

In table 4.31 shows the summarization of financial feasibility which calculated Net present value, internal rate of return, return on capital employed and pay back period. The calculation supports that the investment in new production system is feasible.

4.7 Risk management

As the feasibility study has been conducted, investment risk that affected to the investment plan is the next thing that company should consider. The company has to identify risk that will affect investment program and evaluate the impact of each risks. In order to identify investment risk, the company has setup the risk team which is

- **Factory manager** graduated in bachelor degree of industrial engineering and has experience in operating plastic manufacturing factory for 30 years. His responsibilities are managing and operating the production in the factory and also managing development program.
- **Senior financial officer** graduated in master degree of management and worked for the company for more than 10 years. He has experience in plastic industry for more than 10 years. His responsibilities are managing financial aspects in the factory and take care of investment program inside the factory in financial aspects.

- **Senior marketing officer** graduated in bachelor degree of marketing. He has experience in plastic industry for more than 10years. He has worked for the company for 8 years**.** His responsibilities are taking care of sale volume from the customer, collecting statistic about marketing such as sale volume, market size, price, and etc.
- **Senior engineering officer** graduated in bachelor degree of industrial engineering. He has worked for company for 5 years. His responsibilities are managing battery case production department, develop production line to provide high quality of product and reducing cost.
- **Junior engineering officer** is graduated in bachelor degree of industrial engineering and working for company for 3 years. His responsibilities are to plan the production and collect production and maintenance data. He is familiar with battery production process and all of workers.

4.7.1. Risk management process

The risk team is conducted meeting in order to identify risk and evaluate impact of risk that affected to investment program. In order to identify and evaluate risk, the risk team has arranged 4 times of meeting. In the first meeting, team has been informed the objectives of risk program, generated risk priority number scoring criteria which are severity, occurrence and detection, and asked to think of risk that will affect to investment program internally and externally of the company. In the second meeting, each risk team member presents his ideas individually then summarizes the idea. Then team was asked to scoring all risks by their experience individually. In the third meeting, the discussion of their scoring of each risk has been conducted and then calculated the risk priority number. After all risks have been calculated into the risk priority number, the team was asked to think of preventive action for critical risk individually and discusses in the forth meeting. The forth meeting is conducted to gather and discuss preventive action for each critical risk and then summarize the preventive action for the development program.

4.7.2. Risk priority number rating and criteria

Risk priority number rating and criteria has been asked to set up in the first meeting in order to limit range of risk that each member should concern and lead their work in the same direction. Risk priority number consists of 3 factors which are severity, occurrence and detection. The scope of those factors is as following

- **Severity of risk**

  The severity of risk is a factor that describes impact of damage that has caused risk. The severity can be measured by many vital aspects such as cost, quality, time, harmful to life and etc. To select the measure criteria for severity factor, it depends on the project that risk management program has been implement. In this project, cost and quality are selected for severity criteria which are rated from 1-10, which 1 is the least severe and 10 is the most severe. The criteria and rating score for severity factor show in table 4.32.

- **Detection of risk**

  The detection of risk is factor that describes the ability to detect the risk or failure that will be happen. The detection can be measured by many ways such as controlling method, responsibility of related people and etc. The detection of risk factor is rated from 1-10 which 1 is used for the risk can be detected easiest and 10 is used for impossible detection. The criteria and rating score for detection factor show in table 4.33.

- **Occurrence of risk**

  The occurrence of risk is factor that describes the frequency of failure or risk which occurs in a specific of time. The occurrence of risk criteria can be determined by using percentage of probability, frequency in a period of time and etc, depends on the project. The rating of occurrence factor is rated from 1-10 which 1 is the least frequency and 10 is the most frequency. The criteria and rating score for occurrence factor show in table 4.34.

Table 4.32 The criteria and rating of severity factor

Severity effect	Lost of annual revenue effect criteria	Product quality and injury effect criteria	Score
Hazardous effect	Effect cause more than 10,000,000 THB lost	Failure occurs unexpectedly; harmful to life	10
Serious effect	Effect cause 5,000,000 - 10,000,000 THB lost	Production line is completely shutdown; safety problem	9
Very high effect	Effect cause 3,000,000 - 5,000,000 THB lost	Production line may not operate, severe injury	8
High effect	Effect cause 1,000,000 - 3,000,000 THB lost	Production line may not operate, serious injury	7
Moderate effect	Effect cause 500,000 - 1,000,000 THB lost	Cause customer to seek for replacement; cause injury	6
Low effect	Effect cause 100,000 - 500,000 THB lost	Cause customer to seek for rework; cause small injury	5
Very low effect	Effect cause 50,000 - 100,000 THB lost	Cause customer complaint	4
Minor effect	Effect cause 25,000 - 50,000 THB lost	Minor effect which customer concern but does not request for replacement	3
Very minor effect	Effect cause 10,000 - 25,000 THB lost	Very minor effect which customer does not concern	2
No effect	Effect cause 10,000 THB or less lost	The effect is not affected to quality of product	1

Table 4.33 The criteria and rating of detection factor

Detection rate	Production criteria	External factor criteria	Score
Almost impossible	Can not be detected	Can not be detected	10
Very remote	Detectable by experts and consultant inspection	Detectable from intensive analysis by experts and consultant	9
Remote	Detectable by high level management inspection (Owner, factory manager, financial manager)	Detectable by experts and consultant inspection	8
Very low	Detectable by middle level management inspection (Senior officer, experienced officer)	Detectable by high level management inspection (Owner, CEO, CFO)	7
Low	Detectable by failure report	Detectable by middle level management (Marketing manager, financial manager)	6
Moderate	Detectable by quality control inspection	Detectable by Senior operator and experienced operator	5
Moderately high	Detectable by skilled operator inspection	Detectable by skilled operator	4
High	Detectable by any operator	Detectable by any operator	3
Very high	Detectable by failure report	Detectable by failure report	2
Almost certain	Detectable by any means of control	Detectable by any means of control	1

Table 4.34 The criteria and rating of occurrence factor

Occurrence rate	Frequency of effect	Criteria	Score
Extremely high	The case happens daily	Extremely frequent happen	10
Very high	The case happens every 2-3 days	Very high frequent happen	9
High	The case happens weekly	High frequent happen	8
Frequent	The case happens every 2-3 weeks	Frequent happen	7
Moderate	The case happens monthly	Moderate frequent happen	6
Occasional	The case happens quarterly	Occasional happen	5
Slight chance	The case happens every half year	Slightly chance happen	4
Very slight	The case happens yearly	Very few chance happen	3
Remote	The case happens every 1-3 years	Remotely happen	2
Extremely remote	The case happens every 3-5 years or more	Unlikely happen	1

4.7.3. Risk identification

The risk identification process started since first meeting by asking member to generate risk list individually and present to risk team in second meeting. After each member present their ideas about risk, then discussion on which risk is appropriate and which risk need adjustment and some risk has been added in the second meeting. At the end of second meeting, team can summarizes all of risk into risk list and also identified possible causes and effects. The summarize of risk list shows in table 4.35 and table 4.36 below.

Table 4.35 Summary of risk list and possible effect and cause

	Risk list	Possible effect	Possible cause
1	Unstable of order volume of customer	Production plan and schedule are not accurate. May not delivery product on time. Affects to raw material planning and pricing	Unstable decision making by customer
2	Unclear customer requirement	Production plan and schedule are not accurate. May not delivery product on time	Unstable decision making by customer, inefficient communication from marketing department
3	Disqualified of raw material	Produce finished goods that does not meet customer requirement and quality standard	Careless, Under standard of raw material quality checking, unreliability supplier
4	Shortage of raw material	May not delivery finished goods on time	Shortage of raw material in the market at that time
5	Raw material delivery delay	May not delivery finished goods on time	Transportation problem, high volume, unreliability of supplier, order wrong specification
6	Reliability of supplier	Delay delivery of raw material, may not delivery finished goods on time, may delivery under standard raw material	Careless, relation between company and supplier, new supplier
7	Insufficient skilled operator	May not delivery finished goods on time, may produce under standard of customer requirement, high defects and wastes	lack of training, unavailable of skilled operator
8	Production system break down	May not delivery finished goods on time, high defect, waste and injury	Poor preventive maintenance plan, operates by unskilled operator
9	Reliability of technology	High defect, waste and production cost. Long lead time production	Compatibility of the system, lack of skilled operator
10	Under standard quality control system	May delivery under standard finished goods to customers, high return and replacement rate	careless, lack of skilled operator, low motivation

Table 4.36 Summary of risk list and possible effect and cause (continue)

	Risk list	Possible effect	Possible cause
11	Packaging problem	Qualified finished goods breakdown, conflict with transportation lead to delay of delivery, high return and replacement rate	Careless, lack of skilled operator, low motivation, lack of efficient packing and labeling system
12	Market recession	Order volume from customer reduce significantly	World economy recession
13	Product price fluctuation	Reduction of profits margin	Customer request for promotion and discount, volume order
14	Raw material price fluctuation	Production cost is rising, profit margin is reducing	raw material price refer to world price, volume order

4.7.4. Risk assessment

After risk list has been generated in second meeting, team is asked to scoring each risk by using risk priority number criteria and rating which generated in first meeting by individually and then present to risk team in third meeting. In the third meeting, each member presents their scoring for each risk by using their experience and expertise, and then team leader lets everyone in risk team to discuss about appropriate of risk rating. The summary of risk rating shows in table 4.37

Table 4.37 Summary of Risk Priority Number of each risk

	Risk list	Severity rate (S)	Occurrence rate (O)	Detection rate (D)	RPN
1	Unstable of order volume of customer	3	4	2	24
2	Unclear customer requirement	3	3	2	18
3	Disqualified of raw material	2	3	2	12
4	Shortage of raw material	3	3	2	18
5	Raw material delivery delay	2	4	2	16
6	Reliability of supplier	3	4	3	36
7	Insufficient skilled operator	2	4	2	16
8	Production system break down	3	3	3	27
9	Reliability of technology	3	2	6	36
10	Under standard quality control system	2	2	4	16
11	Packaging problem	1	3	2	6
12	Market recession	10	2	9	180
13	Product price fluctuation	7	7	6	294
14	Raw material price fluctuation	7	10	6	420

4.7.5. Critical risk evaluation

After Risk Priority number (RPN) has been calculated, the critical risk evaluation has to be conducted. To evaluate critical risk, Pareto analysis will be a useful tool. In this case, 80% of total RPN will be 20% of number of risk in order to evaluate critical risk. There are several steps which have to be carried out in order to conduct Pareto analysis. Those steps are as following

1. Reorder all risk by sorting Risk Priority Number from highest to lowest
2. Calculates total cumulative Risk Priority Number
3. Calculate 80% of total cumulative Risk Priority Number
4. Calculate 20% of number of risk
5. Determine accumulating Risk Priority Number that equal 80% of total cumulative Risk Priority Number and cross checking with to number of risk that with in 80% of total cumulative Risk Priority Number should meet 20% of total number of risk
6. Those risks that evaluate by Pareto analysis are critical risk which needed to be managed.

In this case, Risk Priority Number calculation in table 4.16 has been reordered from highest score to lowest score and then calculates cumulative Risk Priority Number as showing in table 4.38

Table 4.38 Reordered of Risk Priority Number of each risk

	Risk list	Severity rate (S)	Occurrence rate (O)	Detection rate (D)	RPN	Cumulative RPN
14	Raw material price fluctuation	7	10	6	420	420
13	Product price fluctuation	7	7	6	294	714
12	Market recession	10	2	9	180	894
6	Reliability of supplier	3	4	3	36	930
9	Reliability of technology	3	2	6	36	966
8	Production system break down	3	3	3	27	993
1	Unstable of order volume of customer	3	4	2	24	1017
2	Unclear customer requirement	3	3	2	18	1035
4	Shortage of raw material	3	3	2	18	1053
5	Raw material delivery delay	2	4	2	16	1069
7	Insufficient skilled operator	2	4	2	16	1085
10	Under standard quality control system	2	2	4	16	1101
3	Disqualified of raw material	2	3	2	12	1113
11	Packaging problem	1	3	2	6	1119

After reordered all risk from highest to lowest RPN, the total cumulative RPN is equal to 1119. So 80% of total cumulative RPN is 895.20 and 20% of total number of risks is 2.80. At risk number 3, total cumulative RPN is equal to 894 which is 79.89% of total cumulative RPN. So there are 3 risks that are critical risks which needed to be managed as showing in table 4.39.

Table 4.39 Critical risk from Pareto analysis

	Risk list	Severity rate (S)	Occurrence rate (O)	Detection rate (D)	RPN
14	Raw material price fluctuation	7	10	6	420
13	Product price fluctuation	7	7	6	294
12	Market recession	10	2	9	180

4.7.6. Preventive action

After Risk Priority Number is calculated in the third meeting, every member is asked to generate preventive action by individually and present to risk team in forth meeting. In the forth meeting, each member of risk team have their chance to present their suggestion for preventive plan and discuss which risk can be solve by preventive plan and what is a benefit of each plan. Some plan can be implemented and carried out the benefit solution, some plan need time and opportunity. The preventive plan is summarized into 4 preventive plans which can solve each risk. The preventive plans are listed as follow:

- **More training in every department**

  In order to solve problem which related to skills, training is a very useful method of preventing the happening of risk. To educate staff in operation section, the skilled staff and operator can reduce severity and occurrence of risk and also increase detection ability. In addition, to educate staff in marketing department, marketing team can communicate and rising negotiation ability.

  Preventive risk number: 12, 13, 14

  Benefits of preventive plan

  Higher quality of production
  Machine breakdown reduction
  Replacement and returned product rate reduction
  Increasing analytical skilled to analysis staff
  Increasing negotiation skilled to marketing staff

  Effecting SOD: Lower severity, occurrence and detection

- **Communicate with customers**

  To prevent the problem with unstable volume order from each customer which will lead to master resource planning and production planning, this preventive plan can be implement. To communicate with the customers to provide the company order forecasting even in monthly or quarterly, this action leads the company to be able creates master resource planning and production planning. This preventive method also provides ability to negotiate with the supplier about raw material price and raw material volume needed.

  Preventive risk number: 13, 14

  Benefits of preventive plan

  Be able to generate master resource planning accurately

  Be able to know quantity needed from customer and generate production plan accurately.

  Be able to negotiate with supplier about pricing and quantity needed

  Prevent shortage of raw material by forecasting quantity raw material needed

  Effecting SOD: Lower severity, occurrence and detection

- **Communicate with supplier**

  After the company can communicates with the customers and gets the forecasts from them, the company can use this information in order to negotiate with supplier. With the volume of order that forecast by customers, the company has buying power in order to get raw material in a good price and let the supplier prepare raw material for the company. In addition, this preventive action can eliminated raw material delivery delay and disqualified raw material.

  Preventive risk number: 14

Benefits of preventive plan

Prevent disqualified raw material

Prevent shortage of raw material

Prevent delay delivery of raw material

Be able to get material in a good price

Effecting SOD: Lower severity, occurrence and detection

- **More frequently meeting between department**

  To manage the manufacturing factory efficiently, the meeting between departments is a channel for each department to communicate through the meeting about the problem or customer complaints that happen. In addition, everyone will understand the each other situation and problem so everyone go straight forward at the same understanding. This meeting also can get suggestion from other department in order to continue development by implement house of quality or voice of quality.

  Preventive risk number: 12, 13, 14

  Benefits of preventive plan

  Reduce mistaking order of raw material

  Reduce probability of raw material shortage situation

  Let the related department to know problem

  Improving efficiency of production

  Marketing team can know situation of raw material situation in order to negotiate with customer

  Procurement team know situation of forecasting order from customer in order to negotiate with suppliers

  Effecting SOD: Lower severity, occurrence and detection

According to result of risk management program is showed as above, the investment risks have been identified in 14 risks and 4 preventive action plans have been generated. But all of risks have been identified and evaluated by basing on existing production system because every member of risk team does not have experienced in new production system. However, the critical risks factors external factors which are product price, raw material price and market status. In addition, by implement new production system, the company can avoid some risks that due to quality such as inefficient skill labor, machine broke down, reliability of technology and packaging problem.

4.8 Conclusion

In this chapter, there are many analyses shown. According to the economic life cycle analysis shows that the replacement can be launched because the existed injection machines have reached its economic service life and the new injection machines which consume less resource can be utilized for at least 9 years or new alternatives shows up. In the other hand, the result of cost of quality analysis also supports replacement program. Then the company decided to replace the production system with new production system. Moreover, the incremental B/C ratio also shows that new production system is providing benefits in acceptable rate. Then the feasibility study is conducted to evaluate the investment program in 3 aspects which are marketing, technology and financial. For marketing aspect, the feasibility study shows that the company is in a first position of the market share even the company losing a little number of market share for 2 years in a row because of incapability to delivery quality finished goods and not able to serve customers satisfaction. In addition, the world economic recession which happened in 2008, led to battery case market recession. Subsequently, there is a good sign by gathering information of quantity of car registered. The new car registration is still increasing even in small growth. At the same time, the domestic car production was reducing with significantly number but there is good sign which is the trend of battery case market seem to start rebounding since March 2009. In addition, the information that can obtain from battery manufacturers shows that the production will be rebounded, creating market opportunities. For technology, new production concept which integrated injection machine with labeling screening machine by using automated robot. The new system consumes less resource (labor, energy, spacing and etc.) than existed system and also

exploited less waste and defect. For financial aspects, the calculation shows that the investment program provides Net present value about 750,428,460.34 THB, Internal rate of return about 119.78%, Return on capital employed about 2634.75% and payback period of the program will be 10 months. From those information that analyze in feasibility study ensures that the investment program is feasible to investment. After the feasibility study is conducted, the risk management program is conducted by risk management team. Risk management team identified risk into 14 risks and also describes possible cause and effect, then assessing those risks by using Risk Priority Number criteria and rating that generated by risk management team. After risk management team scoring all risks, they also generated preventive plans and methods in order to prevent risk to happen or reduce severity and occurrence probability.

To summarize the investment risk assessment in plastic molding machine replacement, the next chapter will conclude all of information and result of analysis. At this point is the end of analysis parts. In the next chapter will conclude all of analysis result, recommendation of development and further studies.

Chapter V

Conclusion and Recommendation

The investment risk assessment in plastic injection molding machine replacement is conducted in order to analyze the investment program that company considers to replace existed battery case production system with new concept of production during the economic recession. This study is a combination of many analyses which determined the existed production system and new production system in different point of view in order to know that the investment program is feasible and launched at appropriate time. At the end of the study, the risk management program is conducted in order to analyze the risks that impact to the development program and generate the preventive action. This chapter will conclude all of the analysis results and also provide recommendation for the study.

5.1 Conclusion

Due to the increasing of operation and maintenance cost of battery production, in year 2008, the company spent 76,045,142.43 Baht in order to deliver 5,082,000 pieces of battery case so the operation and maintenance cost per unit is about 14.96 Baht. In year 2009, the company sold battery case about 5,286,000 pieces which increased from the previous year about 4.01 percent but the company spent 81,830,708.33 Baht for operation and maintenance cost which increased about 7.6 percent and the operation and maintenance cost per unit is about 15.48 baht. But the basic cost of the company which is about 12.346 baht per piece. The operation and maintenance cost that increasing continuously affects to company competitive advantage and profit margin.

Moreover, the availability of high technology and new technique, the company decided to launch the development program by replace the production system with new production concept which is an integrated of high performance plastic injection machine with new cooling part technique and automatic label screening as showing in figure 5.1

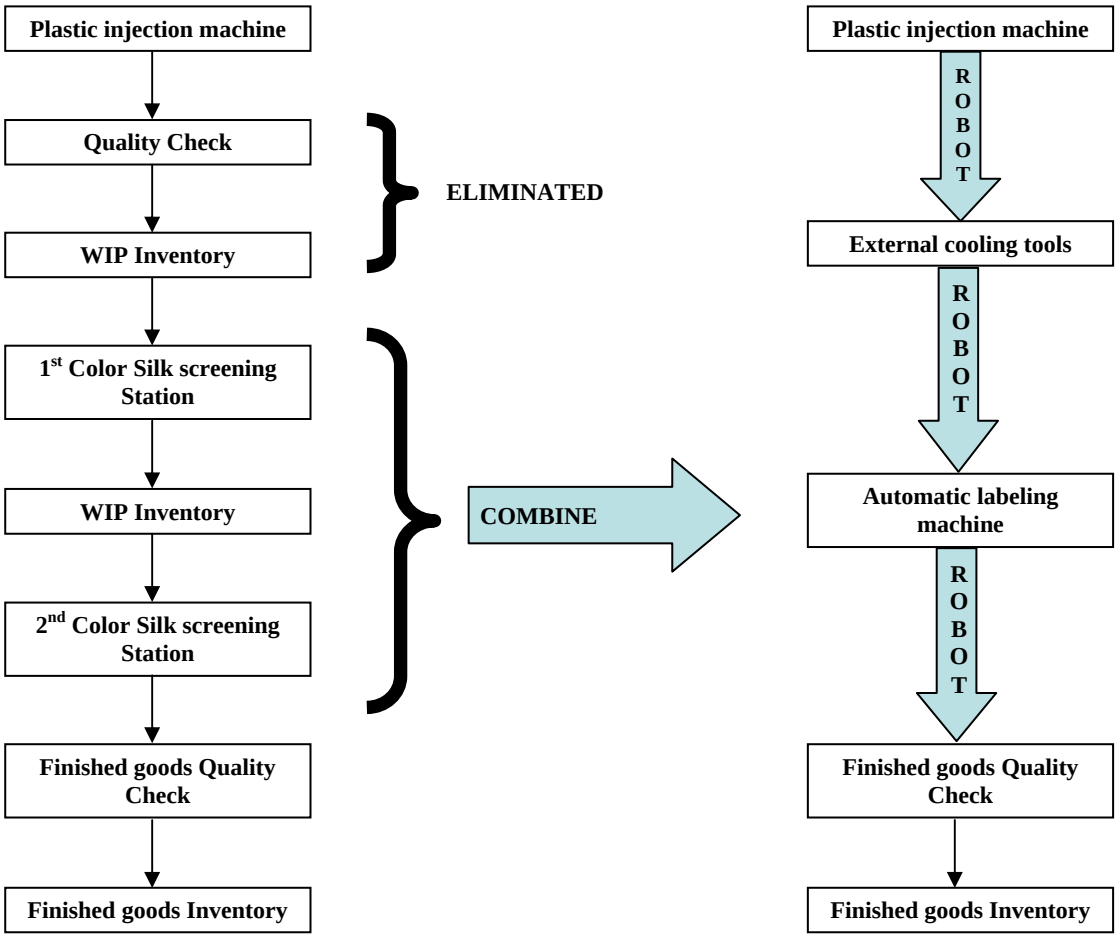

Figure 5.1 Comparison of existed production system and new production system

Before the company makes decision on the investment in new development program, the company has to analyze the existed production system compare to new production system in several aspects.

The economic life cycle analysis is the first analysis that uses to analyze economic service life of existed plastic injection machine in order to know that the machines have passed their own economic life cycle. Moreover, the economic life cycle also uses to analyze useful life of new plastic injection machine in order to know the economic life of machines. According to the analysis, the replacement can be launched because the existed injection machines have reached its economic service life and the new injection machines which consume less resource can be utilized for at least 9 years or new alternatives shows up.

Once economic life cycle analysis is conducted, the cost of quality analysis is required in order to analyze the quality cost of existed production system and compare with the quality cost of new production system. The total quality cost of both production system has been analyzed and converted into unit cost because the production capacity of both system are not equally so the comparison is show in the table below

Table 5.1 Comparison of cost of quality

		Capacity (pieces)	Cost of quality (THB)	Cost of quality per unit (THB/pieces)
1	**Existed production system**	**7,227,000.00**	**53,046,417.22**	**7.340032825**
2	**New production system**	**7,358,400.00**	**9,221,928.39**	**1.253251846**

From the comparison of cost of quality shows that new production system spent less resource than existed production system significantly. These figures support that the replacement of existed production system should be considered.

After cost of quality is conducted, the incremental benefit/Cost analysis is required in order to calculate ratio of incremental benefit and cost which given by new production system compared to existed production system. If the B/C ratio is more than 1.0, so the new production system is appropriate to invest. The incremental B/C ratio also shows that new production system is providing benefits in acceptable rate because the result of the calculation is the increment B/C ratio is about 4.70 .

Table 5.2 Incremental B/C ratio analysis

Description	Existed production system	New production system	Unit
Initial investment	**12,884,901.89**	**108,000,000.00**	**THB**
Annual worth net cash flow	**45,058,211.96**	**94,807,845.31**	**THB**
Annual worth of total cost	**2,096,958.45**	**12,685,639.48**	**THB**
Incremental cost		**10,588,681.03**	**THB**
Incremental benefit		**49,749,633.36**	**THB**
Incremental B/C ratio		**4.70**	

According to economic life cycle analysis, cost of quality analysis and incremental B/C ration analysis results, the company decided to launch the replacement program. In order to know that the replacement program is feasible and the company invests at an appropriate time the feasibility study is required to conduct in 3 main aspects which are marketing, technology and financial. For marketing aspects, the feasibility study shows that the company is in a first position of the market share even the company losing a little number of market share for 2 years in a row because of incapability to delivery quality finished goods and not able to serve customers satisfaction. In addition, the world economic recession which happened in 2008, led to battery case market recession. Subsequently, there is a good sign by gathering information of quantity of car that registered. The registration car is still increasing even in small growth. At the same time, the domestic car production was reducing with significantly number but there is a good sign which are the trend of battery case market seem to start rebounding since March 2009. In addition, the information that can get from battery manufacturer shows that the production will be rebounded so there are opportunities in the market. For technology, new production concept which integrated injection machine whit labeling screening machine by using automated robot. The new system consumes less resource (labor, energy, spacing and etc.) than existed system and also exploited less waste and defect. For financial aspects, the calculation shows that the investment program provides Net present value about 750,428,460.34 THB, Internal rate of return about 119.78%, Return on capital employed about 2634.75% and payback period of the program will be 10 months. From those information that analyze in feasibility ensures that the investment program is feasible to investment. After the feasibility study is conducted, the risk management program is conducted by risk management team. Risk management team identified risk into 14 risks and also describes possible effect and cause and then assessing by using Risk Priority Number criteria and rating that generated by risk management team. After risk management team scoring all risks, they also generated preventive plan and method in order to prevent risk to happen or reduce severity and occurrence probability. The critical risk that risk management team analyzed is as show in table 5.3

Table 5.3 Critical risk from Pareto analysis

	Risk list	Severity rate (S)	Occurrence rate (O)	Detection rate (D)	RPN
14	Raw material price fluctuation	7	10	6	420
13	Product price fluctuation	7	7	6	294
12	Market recession	10	2	9	180

After the critical risk has been allocated, the risk management team has generated 4 preventive actions as followings

- **More training in every department**
- **Communicate with customers**
- **Communicate with suppliers**
- **More frequently meeting between department**

In conclusion, the objectives of this research are met and the new production system is feasible to launch the program according to several analyses that support the decision making.

5.2 Recommendation

Even the analysis in this research can cover the objectives of the research and came up with production system replacement with new production system. But there are some tasks that needed to be continued focusing on after implementation of new production system. The risk management program is required to continue monitoring and reviewing because the results of risk management program is came from prediction and forecasting which based on experience of member of risk management team so the results are not completely perfect. The risk management program is needed to continue conduct and review in order to analyze the project more accurate and continue update the preventive action that suit to the risks.

Moreover, the company should continue developing the efficiency of the production system and waste management in order to achieve zero waste production. The study of recycling of defects and wastes that occurs in the production is an interesting study that company should concern. In the other hand, the improvement risk management methodology and risk management team are also should be concerned and continue developing.

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Chanin Hemkamon was born in Bangkok, Thailand on May 21st, 1983. He graduated from King's Mongkut Institute of Technology Ladkrabang with a Bachelor's degree in Telecomunication Engineering, 2005. Later on, he continues to study on management fields in order to acquire managerial skills in engineering by joining Master program of Master of Engineering Business Management which offered by Chulalongkorn University(Thailand) and University of Warwick(United Kingdom) at the Regional Centre for Manuffacturing Systems engineering, Faculty of Engineering, Chulalongkorn University, as a part time student from March 2008 to March 2010.