# CHAPTER 4

# DEVELOPMENT OF KEY PERFORMANCE INDICATORS

The process for developing KPIs will be presented in this chapter. Firstly, the process plan for developing KPIs must be set. Next, a working team is set to brainstorming session to select the appropriate KPIs for this factory. Then, relevant data will be collected to calculate performance value for each KPIs.

## 4.1 Setting the Plan for Developing KPIs

Before developing KPIs, process for developing KPIs has been set. The plans for developing KPIs are summarized as follows.

1. **Set working team**

A working team should be set to enable the various inputs from cross-functional employees in the factory which potentially lead to the appropriate KPIs selection.

2. **Strengths and weaknesses analysis**

Strengths and weaknesses analysis is an effective way of perform the internal analysis of the factory. The working team should identify these factors and develop the actions to improve the strengths and eliminate weaknesses.

3. **Set objectives**

Once the working team has identified the strengths and weaknesses, objectives will be set in corresponding to the improvement of strengths and elimination of weaknesses.

4. **Identify CSFs**

After the working team has identified the objectives, CSFs will be set in corresponding to the objectives.

5. **Collect relevant Performance Indicators (PIs) in production**

The typical PIs in the production will be collected from the related literatures and theories. PIs those can be used in the factory should be identified and studied.

6. **Select KPIs corresponding to functions and CSFs**

The collected PIs will be selected in corresponding to the functions in the factory and the CSFs accordingly. These selected PIs are KPIs of the factory.

7. **Set performance value**

After identifying the KPIs of the factory, the data related to the KPIs will be collected and calculated for performance value.

8. **Verify performance value**

The calculated performance value should be verified using statistic tools.

9. **Summary**

After the working team has KPIs and performance value of each KPIs, the team can analyze and identify the problem of the factory.

Details of the above steps are provided in the next section and process for developing KPIs are illustrated in Table 4.1.

Table 4.1 Process for developing KPIs

| Processes | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Set working team | | | | | | | | | | | | |
| 2. Strengths and weaknesses analysis | | | | | | | | | | | | |
| 3. Set objectives | | | | | | | | | | | | |
| 4. Identify CSFs | | | | | | | | | | | | |
| 5. Collect relevant PIs in production | | | | | | | | | | | | |
| 6. Select KPIs corresponding to functions and CSFs | | | | | | | | | | | | |
| 7. Set performance value | | | | | | | | | | | | |
| 8. Verify performance value | | | | | | | | | | | | |
| 9. Summary | | | | | | | | | | | | |

## 4.2 Setting Working Team

This team is a cross-functional team including of production planning personnel, production manager, pre-raw material supervisor, processing supervisor, packing supervisor, engineer, quality control manager, maintenance manager and factory manager as a chairman. The team is established as a researcher who conducts the meeting, makes decisions, collects data to analyze by using the statistical technique and also include summary and suggestion for the development of KPIs. Meetings and discussions will be set many times to find the appropriate KPIs for this factory.

Normally, the working team must set the criteria for selecting the appropriate KPIs for this factory. The criteria for selecting appropriate KPIs are presented below (Rolstadas, 1995).

1. The KPIs should well align with goal and objectives. Basically the measurement system should help the factory answer the fundamental question of how well we are doing against our objectives.

2. It should encourage emphasis on appropriate areas of business – areas that are critical to the success or failure of the business and among these critical factors.

3. The KPIs should be easy to understand. People on the shop floor level should be able to explain the importance of the measures used to measure their performance and their relation to goal and objectives.

4. It is important to measure in the areas in which improvement made in these areas really relates to the company's ultimate goal, or profitability to be more specific.

Frequently, too much data is collected, much of which would be useless. What is needed is relevant data. To obtain these data, the goal and objectives of the factory should be clearly defined. The way to know the company deeply, strengths and weaknesses analysis must be performed.

## 4.3 Strength and Weakness Analysis

In order to define the objectives of this factory, the working team use internal analysis identified strengths and weaknesses of the factory. According to the team brainstorming, strengths and weaknesses of this factory are identified as follows.

### 4.3.1 Strengths

1. The factory focus on hi-quality products produced under modern manufacturing and quality control process that make the company receives the following prestigious certification from various accreditation bodies; for example, HACCP etc.
2. The factory has low defects.

### 4.3.2 Weaknesses

1. There is high cost manufacturing process or high fixed cost.
2. There is high product price or price premium.
3. There are old facilities in some manufacturing place that need some investment to improve the construction and utility to support the future product.

4. It is unable to cope with demand and supply fluctuation.
5. There is no professional skill employee.
6. There is high machine down time.
7. It is high maintenance cost.

After brainstorming strengths and weaknesses as described above, the team found the way to achieve the factory's goal by setting objectives.

## 4.4 Setting Objectives

"The factory is being one of leaders in the squid snacks industry in Thailand" is the goal. The way to achieve this goal is to set objectives from strengths and weaknesses analysis. Objectives that the team got from brainstorming are as below.

Table 4.2 Identify objectives corresponding to internal analysis

| Strengths | Objectives |
|---|---|
| 1. The factory focus on hi-quality products produced under modem manufacturing and quality control process that make the company receive the following prestigious certification from various accreditation bodies; for example, HACCP etc. | 1. To produce product conforming to specification; appearance, felling, taste and smell<br>2. To follow on the regulation of food safety<br>3. To satisfy customer's need |
| 2. The factory has low defects. | 1. To lower defects<br>2. To produce product conforming to specification; appearance, felling, taste and smell<br>3. To set the standard of production |
| **Weaknesses** | **Objectives** |
| 1. There is high cost manufacturing process or high fixed cost | 1. To reduce the production cost<br>2. To utilize machines effectively |

| | |
|---|---|
| 2. There is high product price or price premium | 1. To reduce the producticn cost<br>2. To utilize machines effectively |
| 3. There are old facilities in some manufacturing place that need some investment to improve the construction and utility to support the future product | 1. To set the standard of production |
| 4. It is unable to cope with demand and supply fluctuation | 1. To delivery product to customer on time<br>2. To produce product on schedule |
| 5. There is no professional skill employee | 1. To reduce the production cost |
| 6. There is high machine down time | 1. To set the standard of production |
| 7. It is high maintenance cost | 1. To reduce the production cost |

From Table 4.2, it can be divided objectives into three groups as cost, quality and delivery as summarize below.

- Cost
    1. To reduce the production cost
    2. To utilize machines effectively
- Quality
    1. To lower defects
    2. To satisfy customer's need
    3. To set the standard of production
    4. To produce product conforming to specification; appearance, felling, taste and smell
    5. To follow on the regulation of food safety
- Delivery
    1. To delivery product to customer on time
    2. To produce product on schedule

After the team set objectives, the next step is to identify critical success factors.

## 4.5 Identify Critical Success Factors

After brainstorming session, the team identified critical success factors corresponding to objectives as shown in Table 4.3.

Table 4.3 Identify critical success factors corresponding to objectives

| Objectives | Critical Success Factor |
|---|---|
| 1. To reduce the production cost (cost) | 1. Raw material usage<br>2. Worker utilization<br>3. Machine utilization<br>4. Production cost<br>5. Maintenance effectiveness |
| 2. To utilize machines effectively (cost) | 1. Machine utilization |
| 3. To lower defects (quality) | 1. Raw material preparation<br>2. Conformity to product specification<br>3. Production efficiency<br>4. Quality inspection |
| 4. To satisfy customer's need (quality) | 1. Conformity to product specification<br>2. Quality inspection |
| 5. To set the standard of production (quality) | 1. Raw material preparation<br>2. Conformity to product specification<br>3. Production efficiency<br>4. Quality inspection<br>5. Machine down time |
| 6. To produce product conforming to specification; appearance, felling, taste and smell (quality) | 1. Conformity to product specification<br>2. Quality inspection |
| 7. To follow on the regulation of food safety (quality) | 1. Conformity to product specification<br>2. Quality inspection |
| 8. To delivery product to customer on time (delivery) | 1. Production planning<br>2. Transfer delay |
| 9. To produce product on schedule (delivery) | 1. Production planning |

According to Table 4.3, the team found that there are 12 corresponding critical success factors from objectives. They are:

1. raw material usage
2. worker utilization
3. production planning
4. machine utilization
5. raw material preparation
6. conformity to product specification
7. transfer delay
8. production efficiency
9. production cost
10. quality inspection
11. machine down time
12. maintenance effectiveness

It can be seen that there are various critical success factors. Next, the team will collect the typical PIs those can be used in the factory.

## 4.6 Collecting Relevant Performance Indicators in Production

This approach starts with collecting the principles of KPIs that can be used to evaluate in the factory from the review of the relevant literatures and theories. The objective of collecting those PIs is to collect all PIs that can be used to evaluate in the factory by not considering the purpose of measure of each PIs.

According to the previous research such as Schroeder (1993), Morrisey (1996), Jones and Schilling (2000), and www.ftpi.or.th, we can gather the different dimensions of PIs and categorized to 5 groups as follows.

- Group 1: PIs involved with labor
- Group 2: PIs involved with product
- Group 3: PIs involved with raw material

- Group 4: PIs involved with production
- Group 5: PIs involved with machine

Some possible measurements for each of these five groups are presented as follows.

- **Group 1: KPIs involved with labor**

1. Performance ratio
2. Average working time of labors (year)
3. Labor cost to product cost ratio
4. Labor cost per units production (Baht/piece)
5. In-line operation idle time ratio
6. Cost of goods sold per employee (Baht/employee)
7. Net profit per employee (Baht/employee)
8. Personal expense to amount of processing ratio
9. Quantity of product per man hour
10. Labor cost to production value ratio
11. Direct labor productivity
12. Indirect labor productivity
13. Percentage of absenteeism
14. Cost of lost production due to labor problems per average number of employees
15. Number of days lost production due to labor problems per number of days worked
16. Number of days lost to absenteeism per number of days worked
17. Number of employees who leave per average number of employees
18. Number of accidents
19. Time lost due to accidents
20. Ratio of supervisors or managers to workforce
21. Percentage of operators fully competent to perform assigned work
22. Man hours paid per unit

23. Man hours paid per unit per production worker (productivity ratio)
24. Value-added per employee

- **Group 2: KPIs involved with product**

1. Percentage of product defects by product
2. Percentage of defect product sent to customer
3. Number of customer complain per no. of good sold
4. Accuracy of inventory status (% accuracy)
5. Value of expired product (Baht/month)
6. Value of product lost (Baht/month)
7. Value of product damaged (Baht/month)
8. Percentage of on-time delivery
9. Incorrect delivery, e.g., sending wrong products, or in wrong quantity, or to incorrect destination
10. Lead time delivery
11. Percentage reduction of cost of inventory from previous year
12. Percentage of product shipped to customer with formal release by quality control
13. Percentage of product processed on time
14. Percentage of inventory accurate or in the proper location during cycle count
15. Percentage of orders shipped on time
16. Percentage of order shipped requiring adjustments
17. Percentage of product returns and warranty claims
18. Percentage of products which pass final test on the first try
19. Average days late

- **Group 3: KPIs involved with raw material**

1. Percentage yield of raw material (kg/piece/year)
2. Raw material cost per unit production (Baht/piece)
3. Defect ratio that occur when using out of specification of raw material

4. Raw material cost to product cost ratio
5. Inventory turnover (time)
6. Raw material cost to production value ratio
7. Accuracy of inventory status (% accuracy)
8. Value of expired raw material (Baht/month)
9. Value of raw material lost (Baht/month)
10. Value of raw material damaged (Baht/month)
11. Percentage of raw material specification changes per specifications issued
12. Percentage of obsolete raw materials
13. Percentage of accurate inventory count per total cycle count
14. Raw material inventory cost
15. Percentage of downtime due to raw materials shortage
16. Percentage reduction of cost of raw material inventory from previous year

- **Group 4: KPIs involved with production**

1. Percentage yield
2. Unit production per month (pieces/month)
3. Non-conform raw material per total raw material used
4. Defect rate found from in-line production
5. Quantity of defect per quantity of production
6. Internal failure cost (scrap & rework)
7. Percentage of quality costs to product costs
8. Product cost per unit (Baht/piece)
9. Incorrect packing per production cycle time
10. Percentage of on-time completions
11. Number of mis-plan production (time/month)
12. Number of delayed lot (lots/month)
13. Actual production time to planed production time
14. Accumulate idle time per month (hours/month)
15. Value of product uncompleted on time (Baht/month)

16. Production cycle time reduction (minute/cycle/year)
17. Unit production per machine (pieces/minute)
18. Labor reduction per production cycle time (man hour/piece/year)
19. Power reduction per production cycle time (Baht/piece/year)
20. Work in process turnover (time)
21. Average lead time on support requests
22. Average delay in deliveries
23. Lead time delivery
24. Power cost to product cost ratio
25. Depreciation to product cost ratio
26. Cost of R&D to product cost ratio
27. Outsourcing cost to product cost ratio
28. Percentage of operations with current detailed process
29. Percentage of unscheduled overtime to total time
30. Percentage of on-time orders shipped to the next department
31. Percentage of lots or pieces accepted versus total lots or pieces
32. Percentage or value of scrapped or reworked output versus total output
33. Percentage of operators checking their work to recognized plans
34. Percentage of unscheduled overtime to straight time
35. Value of rework or scrap per setup
36. Percentage of reworks or rehandles (number of jobs)
37. Percentage of reworks or rehandles (hours)
38. Number or percent of quality assurance defects (by type)
39. Value or percent of scrap by type or cause
40. Number of shipping errors by type or cause
41. Percentage of defects or off-quality by type or cause
42. Number or percent of errors or processing mistakes passed on to other department
43. Number of short lots
44. Percentage of lots or orders completed or shipped on time
45. Frequency of production schedule adjustment

46. Units or value of production behind schedule
47. Average production time by type of product
48. Percentage of actual to standard production
49. Number or percent of hours lost due to scheduling problems
50. Percentage of lots, orders or jobs late due to plant errors
51. Units, hours or days of production backlog
52. Power cost per unit of production
53. Value of inventory shortage
54. Percentage of late deliveries
55. Work in process and finished goods inventory turns
56. Percentage of deviation between actual and planned schedule
57. Percentage of on-time shipment
58. Percentage of overtime attributed to production scheduling
59. Hours of time lost waiting on materials
60. Number of delayed orders
61. Percentage of processes which are under statistical control
62. Percentage of conformance to daily production schedules
63. Percentage of back orders
64. Average lot size per day
65. Percentage job finished on schedule
66. Percentage of job ready to start on time
67. Production schedule changes
68. Value added to incoming materials

- **Group 5: KPIs involved with machine**

1. Machine idle time ratio (%)
2. Total machine down time (hours/month)
3. Time consuming for machine overhaul on schedule (hours/month)
4. Frequency of machine down time (time/month)
5. Mean time between failure (hour/time)
6. Mean time to repair (hour/time)

7. Waiting time for repairing machine (minute)
8. Machine run time since last overhaul (hour)
9. Maintenance cost to product cost ratio
10. Value of machines per employee (Bath/employee)
11. Efficiency of machinery investment ratio
12. Net profit per machine value
13. Percentage of new machine performing as designed
14. Percentage of machine capable of performing within established specifications
15. Number of quality defects due to machine error
16. Percentage of machines on preventive maintenance
17. Percentage or number of machines breakdowns
18. Percentage of machine downtime due to maintenance
19. Ratio of actual to planned machine utilization (hour)
20. Percentage of scheduled downtime
21. Percentage of unscheduled downtime
22. Percentage or hours of maintenance downtime
23. Number, hours, or percent of machine stops due to operator errors
24. Number of machines fully complemented with capable tools
25. Ratio of setup time to available time
26. Percentage of machine downtime due to parts shortage
27. Percentage of utilization of manufacturing facilities
28. Percentage t of manufacturing facilities at maximum utilization
29. Average time of setup machine
30. Percentage of multipurpose machine
31. Performance efficiency

It can be seen that there are many PIs that can be used to evaluate in the factory, therefore, the working team must find the appropriate way to select KPIs these suitable for this factory.

## 4.7 Selecting KPIs Corresponding to Functions and CSFs

The process for selecting PIs to KPIs from the team brainstorming start with identify functions in this factory.

### 4.7.1 Identify Functions in the Factory

The factory has five sections as shown in Figure 3.1. Each section should have KPIs in order to measure their performances. Before identifying KPIs that relevance in each section, the working team must define functions in each section because KPIs should set along with the functions in order to cover control and measure all performances in factory. According to the team brainstorming, the functions of each section in this factory are identified as shown in Figure 4.1.

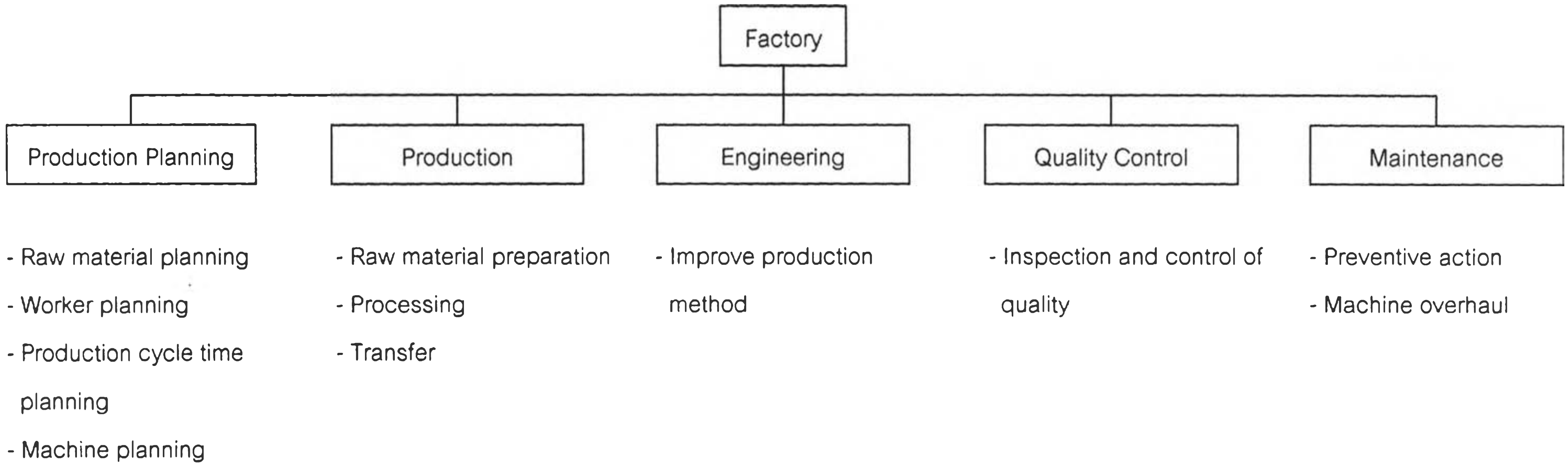


Figure 4.1 Functional diagram of the factory

Due to Figure 4.1, functional diagram defined the functions of each department in this factory as follows:

1. Production planning
    1) Raw material planning
    2) Worker planning
    3) Production cycle time planning
    4) Machine planning
2. Production
    1) Raw material preparation
    2) Processing
    3) Transfer
3. Engineering
    1) Improve production method
4. Quality control
    1) Inspection and control of quality
5. Maintenance
    1) Preventive action
    2) Machine overhaul

After identifying the functions of each department, the team groups all KPIs corresponding in each function as follow.

Table 4.4 List of all PIs corresponding in each function

| Production Planning | |
|---|---|
| **Function** | **KPIs** |
| 1. Raw material planning | Raw material cost per unit production (Baht/piece)<br>Raw material cost to product cost ratio<br>Inventory turnover (time)<br>Raw material cost to production value ratio<br>Accuracy of inventory status (% accuracy)<br>Value of expired raw material (Baht/month)<br>Value of raw material lost (Baht/month) |
| 2. Worker planning | Performance ratio<br>Average working time of labors (year)<br>Labor cost to product cost ratio<br>Labor cost per units production (Baht/piece)<br>In-line operation idle time ratio<br>Cost of goods sold per employee (Baht/employee)<br>Net profit per employee (Baht/employee)<br>Personal expense to amount of processing ratio<br>Quantity of product per man hour<br>Labor cost to production value ratio<br>Direct labor productivity<br>Indirect labor productivity<br>Actual production time to planed production time<br>Percentage of absenteeism<br>Man hours paid per unit per production worker (productivity ratio) |
| 3. Production cycle time planning | Value of product uncompleted on time (Baht/month)<br>Unit production per month (pieces/month)<br>Outsourcing cost to product cost ratio<br>Machine idle time ratio (%)<br>Production schedule changes |

| | |
|---|---|
| 4. Machine planning | Value of machines per employee (Baht/employee)<br>Efficiency of machinery investment ratio<br>Net profit per machine value |
| **Production** | |
| **Function** | **KPIs** |
| 1. Raw material preparation | Defect ratio that occur when using out of specification of raw material<br>Non-conform raw material per total raw material used |
| 2. Processing | Incorrect packing per production cycle time<br>Percentage of on-time completions<br>Number of mis-plan production (time/month)<br>Work in process turnover (time) |
| 3. Transfer | Number of delayed lot (lots/month)<br>Accumulate idle time per month (hours/month)<br>Average delay in deliveries<br>Percentage of on-time delivery<br>Incorrect delivery, e.g., sending wrong products, or in wrong quantity, or to incorrect destination.<br>Lead time delivery |
| **Engineering** | |
| **Function** | **KPIs** |
| 1. Improve production method | Percentage yield of raw material (kg/piece/year)<br>Percentage yield<br>Units production per machine (pieces/minute)<br>Product cost per unit (Baht/piece)<br>Production cycle time reduction (minute/cycle/year)<br>Labor reduction per production cycle time (man hour/piece/year)<br>Power reduction per production cycle time (Baht/piece/year)<br>Power cost to product cost ratio<br>Depreciation to product cost ratio<br>Average lead time on support requests |

| Quality Control | |
|---|---|
| **Function** | **KPIs** |
| 1. Inspection and control of quality | Quantity of defect per quantity of production<br>Defect rate found from in-line production<br>Percentage of defect product sent to customer<br>Percentage of product return<br>Number of customer complain per number of good sold<br>Internal failure cost (scrap & rework) |
| **Maintenance** | |
| **Function** | **KPIs** |
| 1. Preventive action | Total machine down time (hours/month)<br>Time consuming for machine overhaul on schedule (hours/month)<br>Frequency of machine down time (time/month)<br>Mean time between failure (hour/time)<br>Mean time to repair (hour/time) |
| 2. Machine overhaul | Waiting time for repairing machine (minute)<br>Machine run time since last overhaul (hour)<br>Maintenance cost to product cost ratio |

According to Table 4.4, it can be seen that there are many PIs that can be used to evaluate in the factory. Next, the working team will categorize CSFs corresponding to each function.

#### 4.7.2 Identify Critical Success Factors Corresponding to Functions

After brainstorming session, the team can categorize critical success factors to each function as shown in Table 4.5.

Table 4.5 Identify critical success factors corresponding to functions

| Production Planning | |
|---|---|
| **Function** | **Critical Success Factors** |
| 1. Raw material planning | Raw material usage |
| 2. Worker planning | Effective worker utilization |
| 3. Production cycle time planning | Appropriate production planning |
| 4. Machine planning | Machine utilization |
| **Production** | |
| **Function** | **Critical Success Factors** |
| 1. Raw material preparation | Raw material preparation |
| 2. Production | Conformity to product specification |
| 3. Transfer | Transfer delay |
| **Engineering** | |
| **Function** | **Critical Success Factors** |
| 1. Improve production method | Improve production efficiency<br>The ability of reducing production cost |
| **Quality Control** | |
| **Function** | **Critical Success Factors** |
| 1. Inspection and control of quality | The ability of quality inspection |
| **Maintenance** | |
| **Function** | **Critical Success Factors** |
| 1. Preventive action | Machine down time |
| 2. Machine overhaul | Maintenance effectiveness |

### 4.7.3 Identify KPIs Corresponding to Functions and Critical Success Factors

To perform KPIs in the factory, the team will select the appropriate PIs from Table 4.4 corresponding to functions and critical success factors. The important thing that the team has to realize before selecting PIs is all selected PIs must be truly critical to all functions in the factory. After the working team brainstorm, the result 19 KPIs are appropriate for this factory. There are:

1. Raw material cost per unit production (Baht/piece)
2. Defect ratio that occur when using out of specification of raw material
3. Raw material cost to product cost ratio
4. Inventory turnover
5. Performance ratio
6. Value of product uncompleted on time (Baht)
7. Machine idle time ratio (%)
8. Non-conform raw material per total raw material used
9. Quantity of defect per quantity of production
10. Number of delayed lot (lots/period)
11. Accumulate idle time (hours/period)
12. Unit production per machine (pieces/minute)
13. Product cost per unit (Baht/piece)
14. Power cost to product cost ratio
15. Depreciation to product cost ratio
16. Number of customer complain per number of good sold
17. Defect rate found from in-line production
18. Total machine down time (hours/period)
19. Maintenance cost to product cost ratio

It can be categorized the KPIs to each function and critical success factors as shown in Table 4.6.

Table 4.6 The appropriate KPIs for the factory

| Production Planning | | |
|---|---|---|
| **Function** | **Critical Success Factors** | **KPIs** |
| Raw material planning | Raw material usage | 1. Raw material cost per units production (Baht/piece)<br>2. Defect ratio that occur when using out of specification of raw material<br>3. Raw material cost to product cost ratio<br>4. Inventory turnover |
| Worker planning | Effective worker utilization | 5. Performance ratio |
| Production cycle time planning | Appropriate production planning | 6. Value of product uncompleted on time (Baht) |
| Machine planning | Machine utilization | 7. Machine idle time ratio |
| **Production** | | |
| **Function** | **Critical Success Factors** | **KPIs** |
| Raw material preparation | Raw material preparation | 8. Non-conform raw material per total raw material used |
| Production | Conformity to product specification | 9. Quantity of defect per quantity of production |
| Transfer | Transfer delay | 10. Number of delayed lot (lots/period)<br>11. Accumulate idle time (hours/period) |
| **Engineering** | | |
| **Function** | **Critical Success Factors** | **KPIs** |
| Improve production method | Improve production efficiency | 12. Unit production per machine (pieces/minute) |
| | The ability of reducing production cost | 13. Product cost per unit (Baht/piece)<br>14. Power cost to product cost ratio<br>15. Depreciation to product cost ratio |

| Quality Control | | |
|---|---|---|
| **Function** | **Critical Success Factors** | **KPIs** |
| Inspection and control of quality | The ability of quality inspection | 16. Number of customer complain per number of good sold<br>17. Defect rate found from in-line production |
| **Maintenance** | | |
| **Function** | **Critical Success Factors** | **KPIs** |
| Preventive action | Machine down time | 18. Total machine down time (hours/period) |
| Machine overhaul | Maintenance effectiveness | 19. Maintenance cost to product cost ratio |

Once the 19 KPIs are identified, a meeting is set amongst the working team to agree on the findings. Then the result of the meeting is submitted to the management for further approval.

Therefore, the relation between critical success factors and KPIs in each department is illustrated below.

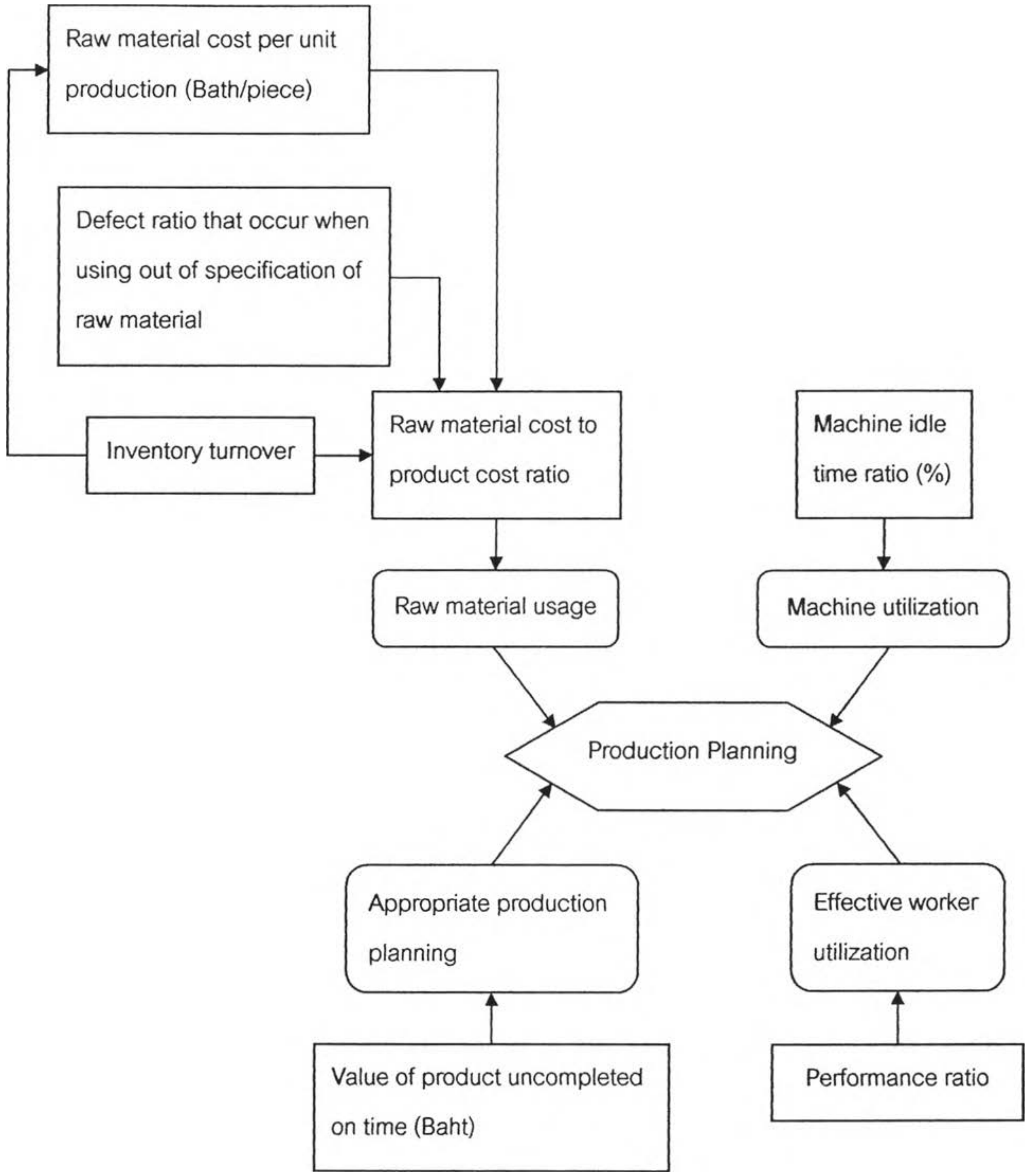


Figure 4.2 Relation chart in production planning

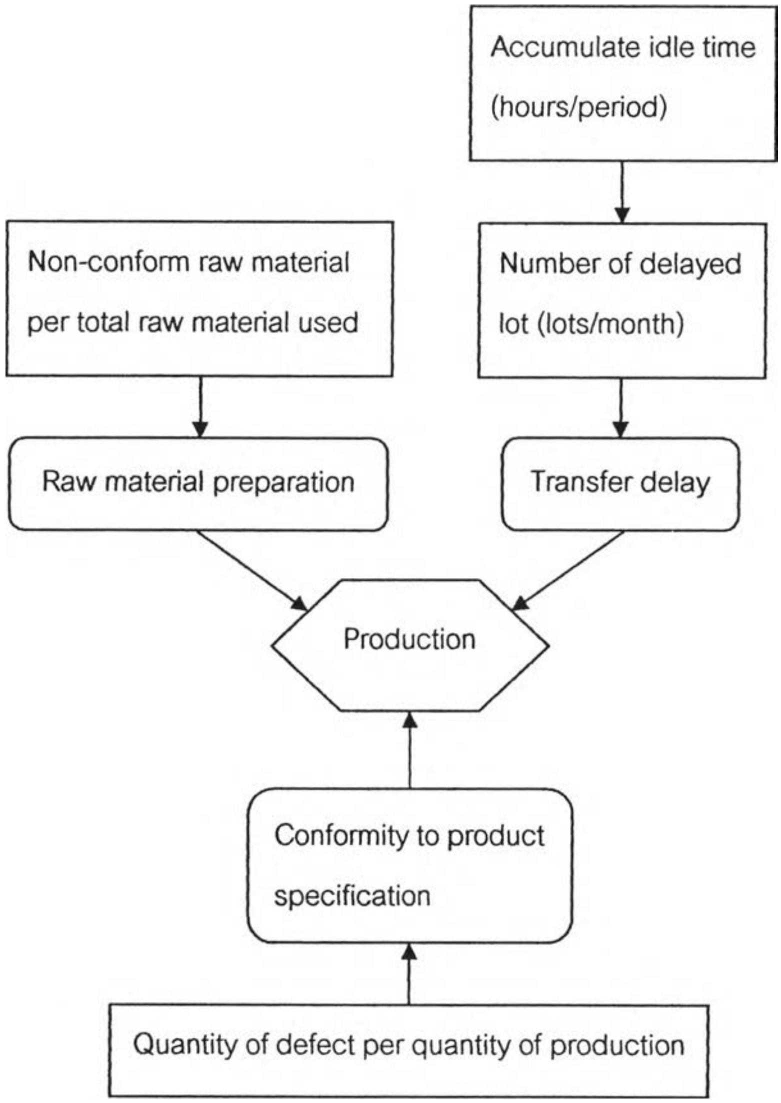


Figure 4.3 Relation chart in production

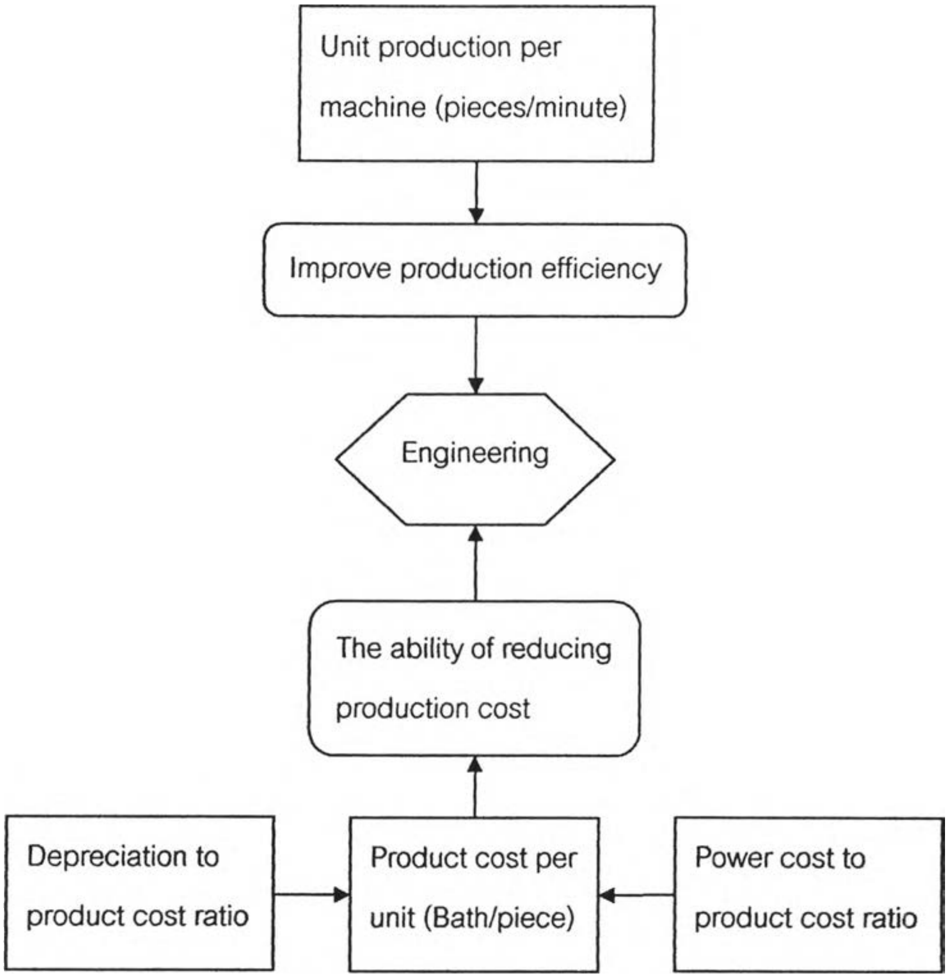


Figure 4.4 Relation chart in engineering

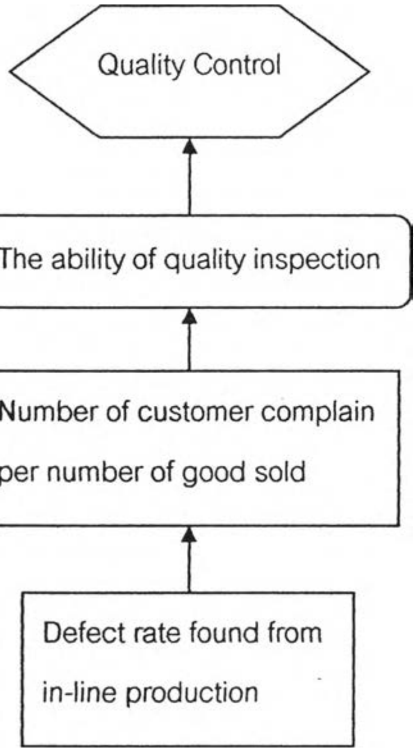


Figure 4.5 Relation chart in quality control

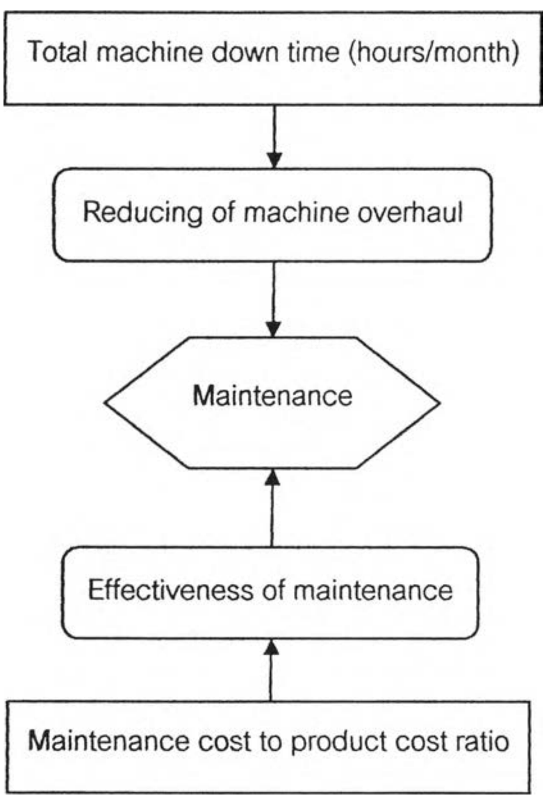


Figure 4.6 Relation chart in maintenance

### 4.7.4 KPIs Explanation

According to 19 selected KPIs, the details of each KPIs are explained as below.

1. Raw material cost per unit production

This index is important because raw material cost is one of crucial variable cost as like as labor cost. If this ratio tends to be increased every month, the factory manager should find the way of how to control this index smoothly or find the new way to contact with supplier in longer term such as fixing the raw material price in 3 or 6 months constantly or search the new raw material for substituting the old one. Therefore, this index ought to be constant or slightly decreased in order to control costs in production easier and more precisely.

2. Defect ratio that occur when using out of specification of raw material

Defect rate shows the quality of raw material. If the defect rate is high, it means that the raw material is off-specification.

3. Raw material cost to product cost ratio

This ratio is quite as similar as the index in number 1 but this ratio includes variable and fixed cost in the process to make one product. It does not include packaging, marketing, or design. Thus, this ratio ought to be consistent.

4. Inventory turnover

Inventory turnover indicates the number of times the stock is turned over during the year. It is calculated by using the total raw material inventory. This KPI is important because high inventory leads to high cost of manufacturing, so control of inventory level is necessary.

5. Performance ratio

This ratio mainly concerns to human factor because if the whole machines are new but the productivity does not increase that means the errors come from workers.

This ratio has many patterns depending upon the character of each job and authority. However, the structure of each project ought to be set as a team to be responsible for each target. If any team can achieve the target, that team will get 100 percent benefit or special bonus for achieving before the due date.

6. Value of product uncompleted on time

The working team selected this KPI in order to measure the performance of appropriate production planning. This KPI will be used for examining the difference value between actual production and production plan. This leads to lose sales opportunity and customer reliability. Therefore, this KPI must be recorded periodically.

7. Machine idle time ratio

This ratio indicates that the frequency of machine stops. If it is high value, that means there are many times the worker breaks the machine. It happens because machine is too old to run, so staffs usually have to fix it.

8. Non-conform raw material per total raw material used

This ratio specifies in a number of defects in the pre-raw material process, which is not conformed or mis-ingredient.

9. Quantity of defect per quantity of production

Defect rate shows the quality of finished product. If the defect rate is high, it means that the production needs to improve immediately.

10. Number of delayed lot

This ratio shows how much the stack time occurs in the process so it has to be a small number.

11. Accumulate idle time

The idle time come from the machine, so the production should consider the machine firstly to check its quality. However, if this index is high, that means the process is organized or planned unsuitably.

12. Unit production per machine

This ratio indicates that the speed of work process. If it is high, that means the capability of that machine is good enough to manufacture products. When the high season arrives or the factory gets high volume of order, this index can help the production decide to select which machine is suitable to produce products more appropriately

13. Product cost per unit

The working team selected this KPI in order to measure the performance of cost of production. Additionally, unit cost is the fundamental factor of every business. It can calculate by combining of every cost to produce one unit of each product. Unit cost will impact directly to the sale price. Thus, the factory manager must contemplate of this measuring.

14. Power cost to product cost ratio

It concerns with the production cost especially for the power cost such as electric or fuel power. For example, nowadays, oil price increase 100 percent comparing last five years so if any business consume oil to make power in the factory, this cause will impact to it directly. Therefore, the factory should search the new power resource, which has quality as similar as oil but the price is more constant.

15. Depreciation to product cost ratio

This ratio indicates how many fixed assets in the factory. If it is high, that means that business has the high value of fixed assets such as land, building or machine.

16. Number of customer complain per number of good sold

Measuring the customer complaint will indicate the customers' satisfaction and any suggestion. The complaint will give benefits to the company to improve and develop the created ideas.

17. Defect rate found from in-line production

Defect rate shows the quality of in-line production. If the defect rate is high, it means that the production needs to improve immediately.

18. Total machine down time

This ratio shows how long the machine breaks down to overhaul it. If this ratio is high, that means the factory should purchase the new one or maintenance the old one closely. However, the factory manager has to weigh the cost between purchasing the new machine and the maintenance cost of the old machine in the next three years with productivity.

19. Maintenance cost to product cost ratio

This cost can help whether the factory manager decides to buy the new machine or not. If it is high, that means the machine has to be taken care closely. Therefore, the manager should compare the maintenance cost and new machine cost that which one is more optimistically.

### 4.7.5 Identify Requirement Data from KPIs

After the working team selected the appropriate KPIs for this factory corresponding to functions and critical success factors, the team has congregation to identify requirement data in order to calculate value of each KPI. These values will illustrate the performance of each production factor. To be able calculating each value, formula of each KPI summarized in Table 4.7.

Table 4.7 Identify requirement data from KPIs

| KPIs | KPIs Formula | Requirement Data | Sort of Data |
|---|---|---|---|
| Raw material cost per unit production (Baht/piece) | $\frac{\text{[Raw material cost]}}{\text{[Unit production]}}$ | ● Raw material cost report<br>● Daily production report | Purchasing<br>Production |
| Defect ratio that occur when using out of specification of raw material | $\frac{\text{[Quantity of defect]} \times 100}{\text{[Quantity of raw material used]}}$ | ● Pre-raw material report<br>● Daily raw material used report | Quality Control<br>Production |
| Raw material cost to product cost ratio | $\frac{\text{[Raw material cost]} \times 100}{\text{[product cost]}}$<br>Product cost = [Raw material cost] + [Labor cost] + [Overhead cost] | ● Raw material cost report<br>● Income & Expenditure report | Purchasing<br>Accounting |
| Inventory turnover | $\frac{\text{[Cost of good sold]}}{\text{[Inventory cost (average)]}}$ | ● Income & Expenditure report<br>● Inventory report | Accounting<br>Accounting |
| Performance ratio | $\frac{\text{[Working time]}}{\text{[Available time]}}$ | ● Machine activity report | Production |
| Value of product uncompleted on time (Baht) | { [Quantity of planning product] – [Quantity of actual product] } x [Value of product] | ● Daily production report<br>● Income & Expenditure report | Production<br>Accounting |

| | | | |
|---|---|---|---|
| Machine idle time ratio (%) | $\left\{1-\left(\dfrac{\text{Loading time} - \text{Break down time}}{\text{Loading time}}\right)\right\} \times 100$ | • Machine activity report | Production |
| Non-conform raw material per total raw material used | $\dfrac{\text{[Quantity of raw material non conform]} \times 100}{\text{[Quantity of raw material used]}}$ | • Pre-raw material report | Quality Control |
| Quantity of defect per quantity of production | $\dfrac{\text{[Quantity of defect]} \times 100}{\text{[Quantity of production]}}$ | • Quality control report | Quality Control |
| Number of delayed lot (lots/period) | Number of lot uncompleted on time | • Delayed lot report | Production |
| Accumulate idle time (hours/period) | [Break down time] + [Idle time]<br>Break down time = [Repairing time] + [Waiting time] for each machine | • Machine activity report | Production |
| Unit production per machine (pieces/minute) | Among of unit production during 1 period per machine | • Daily production report | Production |
| Product cost per unit (Baht/piece) | $\dfrac{\text{[Product cost]}}{\text{[Unit production]}}$<br>Product cost = [Raw material cost] + [Labor cost] + [Overhead cost] | • Income & Expenditure report<br>• Daily production report | Accounting<br>Production |

| | | | |
|---|---|---|---|
| Power cost to product cost ratio | $\frac{\text{[Power cost]} \times 100}{\text{[Product cost]}}$<br>Product cost = [Raw material cost] + [Labor cost] + [Overhead cost] | ● Income & Expenditure report | Accounting |
| Depreciation to product cost ratio | $\frac{\text{[Depreciation]} \times 100}{\text{[Product cost]}}$<br>Product cost = [Raw material cost] + [Labor cost] + [Overhead cost] | ● Income & Expenditure report | Accounting |
| Number of customer complained per number of good sold | $\frac{\text{[Number of customer complained]} \times 100}{\text{[Number of good sold]}}$ | ● Customer complained report<br>● Income & Expenditure report | Quality Control<br>Accounting |
| Defect rate found from in-line production | $\frac{\text{[Quantity of defect found from in-line production]} \times 100}{\text{[Quantity of production]}}$ | ● Quality control report | Quality Control |
| Total machine down time (hours/period) | Number of hours of machine out of order | ● Machine activity report (summary) | Maintenance |
| Maintenance cost to product cost ratio | $\frac{\text{[Maintenance cost]} \times 100}{\text{[Product cost]}}$<br>Product cost = [Raw material cost] + [Labor cost] + [Overhead cost] | ● Income & Expenditure report | Accounting |

## 4.8 Setting Performance Value

After the working team selected the appropriate KPIs for this factory, the team will calculate the performance value of each KPIs. Due to the factory did not collect some requirement data, set new report system must be performed.

### 4.8.1 Setting Report System

Accuracy data are required for calculating performance value. Although the factory has existing report system, it is not to provide all requirement data. Therefore, the KPIs team has to set the new report system to collect all requirement data, and, to calculate the standard value of each KPIs. The new report systems that KPIs team set are:

1. Pre-raw material report
2. Daily production report
3. Quality control report
4. Machine activity report
5. Product transfer
6. Customer complained report
7. Delayed lot report

Table 4.8 Pre-raw material report

Pre-Raw Material Report

Date.............................................

Operator Name...............................

| Time | Quantity of raw material used (Kg.) | Quantity of defect that occur when using out of specification of raw material (Kg.) | Quantity of non-conform raw material (Kg.) |
|---|---|---|---|
| 08.00-10.00 | | | |
| 10.00-12.00 | | | |
| 13.00-15.00 | | | |
| 15.00-17.00 | | | |
| **Summary** | | | |

Remark :

Approved by.................................

Table 4.9 Daily production report

## Daily Production Report

Date..........................................

Operator Name.............................

Production planning..................Kg.

| Time | Raw Material Used | | Unit Production | |
|---|---|---|---|---|
| | Lot | Kg. | Kg. | Pieces |
| 08.00-10.00 | | | | |
| 10.00-12.00 | | | | |
| 13.00-15.00 | | | | |
| 15.00-17.00 | | | | |
| **Summary** | | | | |

Remark :

Approved by................................

Table 4.10 Quality control report

Quality Control Report

Date………………………………..……….

Operator Name……………………………

| Time | Unit Production | | Quantity of defect (Kg.) | |
|---|---|---|---|---|
| | Kg. | Pieces | In-line | Finished product |
| 08.00-10.00 | | | | |
| 10.00-12.00 | | | | |
| 13.00-15.00 | | | | |
| 15.00-17.00 | | | | |
| **Summary** | | | | |

Remark :

Approved by………………………………

Table 4.11 Machine activity report

## Machine Activity Report

Machine Name........................ Machine No..........

Date....................................

Operator Name.......................

Operator check in...................(morning) Check out.................

Operator check in.................(afternoon) Check out.................

| Task | Starting Time | Finishing Time |
|---|---|---|
| 1. Start up | | |
| 2. Run | | |
| 3. Troubleshooting | | |
| 4. Re-preparing | | |
| 5. Re-run | | |
| 6. Cleaning | | |

Working Time (min)..............................

Loading Time (min)..............................

Machine Down Time (min)....................

Idle Time (min)...................................

Remark :

Approved by................................

Table 4.12 Product transfer

## Product Transfer

Book Number.................. Number.................

Date .............................

Operator Name....................................

| Order | Item | Lot | Quantity (Kg.) |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Remark :

Approved by................................

Table 4.13 Customer complained report

| Customer Complained Report |
| --- |
| Date.................................. <br> Customer Name............................................ <br> Product....................................................... <br> Quantity............................. |
| Complained : |
| Cause and effect : |
| Reporter.................................. |

Table 4.14 Delayed lot report

Delayed Lot Report

Period..............................

| Lot | Product | Ordered Date | Due Date | Completed Date |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Number of delayed lot .....................lots

Approved by......................................

### 4.8.2 Collecting Data

After setting the report system. the working team will collect data in the factory in order to calculate the value of each KPIs to be able to evaluate the performance of the company. The team agreed to calculate the performance value every 15 working days or a period for 3 months.

The examples of collecting data by using the new report system in period 1 are shown in Table 4.15. Additional, Table 4.16 presented all collecting data in order to calculate the performance value.

Table 4.15 Collecting data in period 1

| Day | Raw material used (Kg.) | Unit production (Kg.) | Unit production (pieces) | Quantity of defect that occur when using out of specification of raw material (Kg.) | Quantity of non-conform raw material (Kg.) | Unit defect (Kg.) | Defect rate found from in-line production (Kg.) | Working time (min) | Loading time (min) | Break down time (min) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1,120.00 | 1,029.01 | 34,300 | 19.39 | 28.75 | 19.58 | 23.27 | 460 | 480 | 25 |
| 2 | 1,070.00 | 977.40 | 32,580 | 21.70 | 22.22 | 15.94 | 31.09 | 464 | 487 | 18 |
| 3 | 1,130.00 | 1,038.50 | 34,617 | 27.64 | 27.82 | 18.73 | 15.76 | 459 | 480 | 25 |
| 4 | 1,160.00 | 1,069.20 | 35,640 | 28.54 | 20.07 | 16.93 | 22.64 | 461 | 481 | 24 |
| 5 | 1,090.00 | 1,028.60 | 34,287 | 19.99 | 6.33 | 20.02 | 13.06 | 445 | 469 | 21 |
| 6 | 1,120.00 | 1,043.20 | 34,773 | 13.02 | 16.95 | 21.76 | 22.96 | 449 | 490 | 15 |
| 7 | 1,100.00 | 1,004.70 | 33,490 | 15.49 | 35.98 | 21.06 | 21.45 | 445 | 468 | 22 |
| 8 | 1,020.00 | 940.50 | 31,350 | 20.87 | 21.11 | 17.12 | 17.95 | 450 | 481 | 14 |
| 9 | 1,030.00 | 926.34 | 30,878 | 24.62 | 30.69 | 21.85 | 25.10 | 438 | 459 | 24 |
| 10 | 1,030.00 | 953.45 | 31,782 | 22.86 | 9.58 | 22.13 | 19.97 | 442 | 471 | 16 |
| 11 | 1,120.00 | 1,028.61 | 34,287 | 25.76 | 18.52 | 23.41 | 21.69 | 434 | 457 | 22 |
| 12 | 1,070.00 | 986.50 | 32,883 | 23.37 | 21.56 | 20.61 | 16.95 | 443 | 484 | 20 |

| Day | Raw material used (Kg.) | Unit production (Kg.) | Unit production (pieces) | Quantity of defect that occur when using out of specification of raw material (Kg.) | Quantity of non-conform raw material (Kg.) | Unit defect (Kg.) | Defect rate found from in-line production (Kg.) | Working time (min) | Loading time (min) | Break down time (min) |
|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 1,080.00 | 991.60 | 33,053 | 19.36 | 28.39 | 18.17 | 21.06 | 441 | 490 | 15 |
| 14 | 1,130.00 | 1,048.10 | 34,937 | 22.20 | 20.34 | 19.49 | 18.87 | 439 | 481 | 24 |
| 15 | 1,080.00 | 986.94 | 32,898 | 30.59 | 18.35 | 15.32 | 28.80 | 437 | 485 | 20 |
| Summary | **16,350.00** | **15,052.65** | **501,755** | **335.40** | **326.66** | **292.13** | **320.62** | **6,707** | **7,164** | **305** |

Table 4.16 Collecting data in period 1 – 6

| Data | Unit | Period | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| Raw material cost | Baht | 1,962,000 | 1,932,000 | 1,968,000 | 1,980,000 | 1,968,000 | 1,968,000 |
| Total raw material used | Kg. | 16,350 | 16,100 | 16,400 | 16,500 | 16,400 | 16,400 |
| Unit production | Kg. | 15,052.65 | 14,843.46 | 15,046.23 | 15,138.78 | 15,056.94 | 15,023.03 |
| Unit production | Pieces | 501,755 | 494,782 | 501,541 | 504,626 | 501,898 | 500,768 |
| Quantity of defect that occur when using out of specification of raw material | Kg. | 335.40 | 329.35 | 332.15 | 329.84 | 326.79 | 334.45 |
| Product cost | Baht | 2,416,568 | 2,313,749 | 2,533,512 | 2,510,370 | 2,405,215 | 2,445,125 |
| Cost of good sold | Baht | 2,634,059 | 2,533,555 | 2,788,383 | 2,753,876 | 2,620,722 | 2,665,186 |
| Quantity of product uncompleted on time | Kg. | 115.47 | 238.91 | 145.38 | 67.52 | 259.06 | 293.61 |
| Quantity of non-conform raw material | Kg. | 326.66 | 318.20 | 328.29 | 332.16 | 326.62 | 328.67 |
| Unit defect | Kg. | 292.13 | 300.50 | 314.20 | 289.57 | 305.84 | 303.82 |
| Defect rate found from in-line production | Kg. | 320.62 | 309.10 | 316.11 | 302.76 | 321.72 | 327.02 |
| Working time (at roaster machine) | Minutes | 6,707 | 6,641 | 6,663 | 6,697 | 6,713 | 6,644 |
| Available time (at roaster machine) | Minutes | 7,200 | 7,200 | 7,200 | 7,200 | 7,200 | 7,200 |
| Loading time (at roaster machine) | Minutes | 7,164 | 7,030 | 7,137 | 7,113 | 7,179 | 7,030 |

| Data | Unit | Period | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| Break down time (at roaster machine) | Minutes | 305 | 386 | 301 | 359 | 309 | 389 |
| Accumulate idle time | Hours | 625 | 698 | 587 | 690 | 426 | 783 |
| Number of delayed lot | Lots | 1 | 2 | 1 | 0 | 2 | 2 |
| Power cost | Baht | 40,438.30 | 39,113.40 | 39,745.90 | 40,872.70 | 39,257.70 | 40,062.70 |
| Labor cost | Baht | 190,000 | 190,000 | 190,000 | 190,000 | 190,000 | 190,000 |
| Depreciation | Baht | 210,000 | 210,000 | 210,000 | 210,000 | 210,000 | 210,000 |
| Number of customer complain | Pieces | 296 | 529 | 635 | 230 | 447 | 627 |
| Number of good sold | Pieces | 488,000 | 487,000 | 455,000 | 460,000 | 475,000 | 507,000 |
| Total machine down time | Hours | 19 | 20 | 15 | 28 | 22 | 13 |
| Maintenance cost | Baht | 21,000.00 | 27,900.50 | 29,014.10 | 21,993.30 | 24,500.00 | 26,298.20 |

### 4.8.3 Calculate Performance Value

When the data is collected completely, the working team will calculate the performance value in order to determine the trend of each KPIs. The performance value of each KPIs are presented in Table 4.17.

Table 4.17 Performance value of KPIs in period 1 – 6

| KPIs | Period | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Raw material cost per unit production (Baht/piece) | 3.91 | 3.90 | 3.92 | 3.92 | 3.92 | 3.93 |
| Defect ratio that occur when using out of specification of raw material | 2.05 | 2.05 | 2.03 | 2.00 | 1.99 | 2.04 |
| Raw material cost to product cost ratio | 81.19 | 83.50 | 77.68 | 78.87 | 81.82 | 80.49 |
| Inventory turnover | 10.24 | | 10.80 | | 10.58 | |
| Performance ratio | 93.15 | 92.24 | 92.54 | 93.01 | 93.24 | 92.28 |
| Value of product uncompleted on time (Baht) | 115,470 | 238,910 | 145,380 | 67,520 | 259,060 | 293,610 |
| Machine Idle Time Ratio (%) | 4.26 | 5.50 | 4.22 | 5.05 | 4.30 | 5.53 |
| Non-conform raw material per total raw material used | 2.00 | 1.98 | 2.00 | 2.01 | 1.99 | 2.00 |
| Quantity of defect per quantity of production | 1.94 | 2.02 | 2.09 | 1.91 | 2.03 | 2.02 |
| Number of delayed lot (lots/period) | 1 | 2 | 1 | 0 | 2 | 2 |
| Accumulate idle time (hours/period) | 625 | 698 | 587 | 690 | 426 | 783 |
| Unit production per machine (pieces/minute) | 69.69 | 68.72 | 69.66 | 70.09 | 69.71 | 69.55 |
| Product cost per unit (Baht/piece) | 4.82 | 4.68 | 5.05 | 4.97 | 4.79 | 4.88 |
| Power cost to product cost ratio | 1.67 | 1.69 | 1.57 | 1.63 | 1.63 | 1.64 |
| Depreciation to product cost ratio | 8.69 | 9.08 | 8.29 | 8.37 | 8.73 | 8.59 |

| KPIs | Period | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Number of customer complain per number of good sold | 0.06 | 0.11 | 0.14 | 0.05 | 0.09 | 0.12 |
| Defect rate found from in-line production | 2.13 | 2.08 | 2.10 | 2.00 | 2.14 | 2.18 |
| Total machine down time (hours/period) | 19 | 20 | 15 | 28 | 22 | 13 |
| Maintenance cost to product cost ratio | 0.87 | 1.21 | 1.15 | 0.88 | 1.02 | 1.08 |

Once the performance values are calculated, a meeting is set amongst the working team to agree on the result. Then the result of the meeting is submitted to the management for approval.

Additionally, according to time constraint in this study, inventory turnover should not be analyzed in this stage due to there are too few data. Anyhow, inventory turnover is one of the critical KPIs and should be recorded for future analysis. Consequently, the rest 18 KPIs will be studied in the next chapter.