

# The Measurement of Quality Performance with Sigma Measurement and Cost of Poor Quality as a Basis for Selection Process of Quality Improvement

Retnari Dian M, Amrin Rapi , and Nilda , Member of IAENG

**Abstract**— The measurement of quality performance can lead to effective and efficient quality improvement. With so many limitations and weaknesses on company process of creating and delivering value, the quality improving process could be a process of selecting priority project. Without having certain quality parameters as a basis, quality improvement process can be ineffective, in a way that the result of the improvement can not have a huge effect on the customer's satisfaction, and neither be efficient, because the improvement often neglect the cost consideration. Using case study at galvanized steel production process on PT X, this paper suggests that measurement of quality performance can become a basis of selection of quality improvement project in manufacturing floor level.

This paper describes how the measurement of quality performance is conducted with Sigma measurement and cost of poor quality, and how by this measurement, the effective and efficient selection process of quality improvement could be done.

**Index Terms**— cost of poor quality, quality performance, Sigma measurement

## I. OVERVIEW

Process of quality control in a company is becoming an important issue, and has to be managed efficiently and effectively. With so many limitations and weaknesses on company process of creating and delivering value, the quality improvement process could be a process of selecting priority project. In a common practice of quality control in the past, it was often that the improvement of quality did not lead to customer's satisfaction, so there is no huge effect of that quality improvement on sales increasing. On improvement processes, the temptation is to improve efficiency, without paying enough attention on how those things will affect the effectiveness of value delivery to customer.

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Retnari Dian M, ST, M.Si , Amrin Rapi, ST, MT and Nilda, ST, MIT are lecturers at Hasanuddin University, Makassar, Indonesia (phone: +62811448119; e-mail: retnaridianm@yahoo.com).

This paper suggests how the selection of quality improvement process should be done. The effective and efficient quality control effort should be commenced on the aspects that become the priority of customer's requirement, and then on the aspects which have quality performance gap.

The rest of the article is organized as follows. In Section 2 and Section 3, the Sigma measurement and Cost of Poor Quality are described consecutively, as two ways of measuring quality performance. In the next section, it is presented a case study in PT X, and described how the measurement of quality performance is conducted –using case study at galvanized steel production process on PT X with Sigma measurement and cost of poor quality, and how this measurement of quality performance can lead to effective and efficient quality improvement process. Finally, it is provided the conclusion on how to select the quality improvement process.

## II. SIGMA MEASUREMENT

Quality performance measurement basically focuses on tracing and minimizing defect of the process. The measurement to find how many defect can give understanding to the measurer about how much gap of quality performance. The gap of quality performance can be compared with the company standard, or standard of other company in the same industry.

There are several benefit on using defect measurement:

- simplicity. Everyone can understand “good” or “bad”. Counting on various type of defect measurement can be done only with basic mathematic.
- consistency. Defect measurement can be applied on every process, whether for continue data or discrete data, whether for manufacturing or service process.
- comparability. Motorola uses Sigma measurement to trace improvement average on every process, and to compare the performance among industry.

Despite all the benefit, there are some weaknesses of defect measurement. With only observing “good” or “bad”, defect measurement can not detect key information on specific data.

The word 'Sigma' is a letter in the Greek alphabet that has become the statistical symbol and metric of process variation. The sigma scale of measure is perfectly correlated to such characteristics as defects-per-unit, parts-per-million defectives, and the probability of a failure. Six sigma implies the number of sigma measured in a process, when the variation around the target is such that only 3.4 outputs out of one million are defects under the assumption that the process average may drift over the long term by as much as 1.5 standard deviations.

Sigma becomes a term that measures how far a given process deviates from perfection. The central idea behind it is that if how many defect can be measured in a process, then it can be systematically figure out how to eliminate them and get as close to 'zero defect' as possible.

With Sigma method, quality performance is measured with percentage of defect, that is variance happened on production process from the average of standard dimension. Sigma measurement can be gained with converting defect found with Sigma conversion table.

The term Six Sigma has evolved into a systematic, scientific, statistical and holistic approach for management innovation which is quite suitable for use in a knowledge-based information society. Six Sigma approach provides a scientific and statistical basis for quality assessment for all processes through measurement of quality levels. The Six Sigma approach allows us to draw comparisons among all processes, and tell how good a process is. Through this information, top-level management learns what path to follow to achieve process innovation and customer satisfaction.

### III. COST OF POOR QUALITY

Companies typically suffer from huge hidden plants, which manifest as the cost of poor quality. By halving this cost, the companies can double their profits without making any capital investments.

Calculating the cost of poor quality allows an organization to determine the extent to which organizational resources are used for activities that exist only as the result of deficiencies that occur in its processes. Having such information allows an organization to determine the potential savings to be gained by implementing process improvements.

Important performance dimension that is not captured in defect measurement or Sigma measurement is dollar impact of defect, or so called "cost of poor quality" or CPQ. For example, if a company has two processes with the same performance  $3.5\sigma$ , thus the defect-basis performance of those two processes apparently will be the same. But, by adding the money loss for defect on those processes, we can find the bottom line effect on one process is much higher than the other process.

Because of that reason, CPQ becomes an important key on starting point of quality measurement. For this, we should interpret problems and defect into cost of money per incident –including cost of operator and material for rework, or for the delivery delay- and also opportunity cost. CPQ measurement can be a very useful way to

strengthen consensus, to improve, and also to help choosing problems with clearer benefit.

The sheer size of internal failure costs, external failure costs and appraisal costs indicate that cost of poor quality (or chronic waste) does not exist as a homogenous mass. Instead, they occur in specific segments, each traceable to a specific cause(s). These segments are unequal in size and a relative few account for a bulk of the costs. Ironically, these costs seldom show in traditional accounting reports. However, quality-related costs are much larger than are commonly understood. For most companies, these costs run in the range of 20 to 30% of sales or 25 to 40% of operating expenses.

Quality costs are not simply the result of factory operations. The support operations including maintenance, human resources and so on, are also major contributors. The bulk of these costs are the result of incapable support processes. Such costs are buried in the standards, but are in fact avoidable. The problem is that while these costs are avoidable, there has been no clear responsibility for action to reduce them. Fortunately, today there are structural approaches for doing so.

The four steps to calculate the Cost of Poor Quality, are as follows

1. Identify all activities that exist only because of poor quality.

Call together a team that includes people with firsthand knowledge of the process. Conduct a brainstorming session to capture all component tasks that exist exclusively to remedy quality problems caused by process deficiencies.

2. Identify where in the organization the cost of each activity is experienced.

These costs may appear in one area or in multiple areas.

3. Determine the method you will use to calculate the cost of poor quality.

4. Collect the data and estimate the costs.

If total resources method is used, things that must be identified are as follow:

- 1) the total resources consumed in a category
- 2) the percentage of those resources used for activities associated with remediating the effects of poor quality.

If unit cost method is used, things that must be identified are as follow:

- 1) the number of times deficiencies occur and
- 2) the average cost for correcting the deficiency.

#### IV. CASE STUDY: SELECTION PROCESS OF QUALITY IMPROVEMENT ON GALVANIZED STEEL PRODUCTION PROCESS IN PT. X

PT X is a galvanized steel producer in eastern part of Indonesia, which positions its products as premium products in market, with price and quality above average compared to other galvanized steel products. With premium product positioning, PT X is required to do the quality controlling process in order to produce high quality products. Under many limitations of sources, PT X needs to choose among several choices of quality improvement processes. In this paper it will be used one example of quality improvement process, which is to reduce product with inconsistent galvanized defect.

The measurement of product with inconsistent galvanized defect will be conducted with two measurement, first is Sigma measurement and the second is cost of poor quality.

For Sigma measurement, the result is 1.4%, for which there are 388 defect products out of observed 27880 products. This percentage of 1.4% is equal to yield  $(27780-388)/27780=0.986$ , or DPMO 14000. From  $\sigma$  table, quality performance for yield 0.986 is around  $3.625\sigma$  to  $3.7\sigma$ . That Sigma quality performance can be analyzed through comparison either with company standard, or industrial standard. Since there is still no industrial standard in galvanized industry in Indonesia, this Sigma performance will be compared to company standard, i.e. the standard that company has set as a target of quality performance. That quality performance is a little bit higher than average quality performance that become company standard, that is  $3.5\sigma$ . Thus by this measurement method, the quality performance of inconsistent galvanized defect still in range of good performance.

Besides measuring defect with Sigma, it is also conducted a measurement of cost of poor quality. The components of cost of poor quality measurement for product with inconsistent galvanized defect are listed below.

1. Rework process, which consists of:
  - Cost of galvanization and supported material
  - Overhead Cost
  - Operator Cost
2. Customer's loss because of receiving defect product
3. Delivery delay cost

For measurement of cost of galvanization and supported material, first it is needed to calculate the cost of galvanization and supported per unit. The measurement of CPQ for cost of galvanization and supported material can be seen in Table 1 below.

For both overhead cost and operator cost, CPQ measurement can be seen in Table 2 and 3 below.

The next step is to count the customer's loss because of receiving defect product. For inconsistent galvanized defect in PT X, inspections are done with 100% inspection method, that is to check all products, instead of sample products. Therefore, all products with inconsistent galvanized defect will be reworked / regalvanized. This

makes no final products with inconsistent galvanized, so that there is no customer's loss because of receiving defect product.

The next element of CPQ to be considered is the cost of delivery delay. Because of the production process in PT X is not make to order, the products are general, and the production planning in PT X is based on historical data, and so far the minimum safety stock decided always can cover the delay caused by reworking. Thus there is no cost of delivery delay in PT X.

Finally the CPQ for defect of inconsistency galvanized can be summarized in Table 4 below. From the Table 4, CPQ for defect inconsistent galvanized is Rp. 3,457 / sheets. If production data on December 2008 is used, for which it was produced 411,569 sheets, and the performance of the process was  $3.7\sigma$ , where the defect was 1.4%, thus the rework products are  $411,569 \times 1.4\% = 5,764$  sheets. Hence in December 2008, the total cost spent for defect of inconsistent galvanized was  $5,764 \text{ sheets} \times \text{Rp. } 3,457 = \text{Rp. } 19.9 \text{ million}$ .

#### V. ANALYSIS OF CASE STUDY

By using the CPQ method, it can be seen that the company spend Rp.19.9 million each month for having that poor quality process of product with inconsistent galvanized. The same figure is represented as around  $3.7\sigma$  in Sigma measurement, which is considered as a good performance since it is above the company standard.

From this case study, it can be seen that the defect with good Sigma performance still can have a big cost of poor quality then it should become the priority of improvement process.

The important performance dimension that is not captured in defect measurement or Sigma measurement is dollar impact of defect, or cost of poor quality. This is especially crucial if the case study involve the two processes with the same Sigma measurement performance. If that is the case, then by adding the money loss for defect on those processes, we can find the bottom line effect on one process is much higher than the other process. Because of that reason, CPQ becomes an important key on starting point of quality measurement. For this, we should interpret problems and defect into cost of money per incident.

Table 1. CPQ Measurement for Cost of Galvanization and Supported Material

Galvanization and Supported Material	Consumption per day (kgs)	Average daily total production (tons)	Material Consumption (kg/ton prod)	Average zinc roll per ton	Material Consumption for each zinc roll (kg/zinc roll)	Unit price (Rp/ton)	Cost of Material (Rp/zinc roll)
Zinc ingot	3,324	29.7	111.919	309	0.362681	4,540,000	1,646.6
Lead ingot	25	29.7	0.842	309	0.002728	2,320,000	6.3
Hydrochloride acid	77	29.7	2.593	309	0.008401	2,738,000	23.0
Ammchloride	14	29.7	0.471	309	0.001528	1,456,000	2.2
S flux	125	29.7	4.209	309	0.013639	1,421,000	19.4
Cromic acid	0.09	29.7	0.003	309	0.000010	8,777,000	0.1
Algava	13	29.7	0.438	309	0.001418	2,335,000	3.3
Heavy oil	1,483	29.7	49.933	309	0.161810	2,327,000	376.5
Flux	8,498	29.7	286.128	309	0.927215	1,422,000	1,318.5
TOTAL							3,396

Assumption: the amount of zinc roll is equal for all products size

Table 2. CPQ Measurement for Overhead Cost

Overhead	Cost per year	Assumption on Usage of galvanizing line	Cost per year for galvanizing line	Total production (sheet/year)	cost (Rp./sheet)
Depreciation	140050000	60%	84030000	3929004	21.4
Reparation and maintenance	168672000	30%	50601600	3929004	12.9
Electricity and fuel	127652000	60%	76591200	3929004	19.5
Waste treatment cost	9639000	100%	9639000	3929004	2.5
TOTAL					56.2

Assumption: overhead cost is equal for all products size

Table 3. CPQ Measurement for Operator Cost

Productive time (hour / month)	Total Production (sheet/month)	Working Time (hour / sheet)	Operator wages (Rp. / hour)	Operator wages (Rp. / sheet)
516	327417	0.002	3082.9	4.9

Assumption: operator cost is equal for all products size

Table 4. Cost of Poor Quality Defect of Inconsistency Galvanized

Type of Cost	Amount (Rp. / sheet)
1. Rework process, which consist of:	
Cost of galvanization and supported material	3396
Overhead cost	56.2
Operator cost	4.9
2. Customer's loss because of receiving defect product	0
3. Delivery delay cost	0
<b>TOTAL</b>	<b>3457</b>

## V. CONCLUSION

First step of selecting process for quality improvement is to measure the performance of quality. The important thing is that the process with the lowest quality performance should become the priority of the improvement process. But the more important thing is that the priority of the improvement process should be the process that will affect the effectiveness of value delivery to customer.

Through Sigma measurement, selection of quality improvement project is based on the process with biggest quality discrepancy from the standard. The selection process of quality improvement that solely rely upon Sigma measurement can lead to the process that has biggest quality discrepancy, without paying enough attention whether that process has significant impact to customer. Since the CPQ measures also the loss that customer suffer because of the defect, such as the late delivery, and opportunity loss because the products do not satisfy them, thus the measurement with CPQ is more reflecting the customer's requirement. The effective and efficient quality control effort should be commenced on the aspects that become the priority of customer's requirement, and then on the aspects which have quality performance gap

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