Implementing Six Sigma in Chinese Manufacturer

Abstract

Today, US companies are increasingly using Chinese part firms as suppliers for materials or parts, especially in manufacturing. Due to the fact that Chinese supplier do not have quality control based on manufacture or producing process, they need to improve the quality of product. Six Sigma is a popular technique currently being used to improve quality. In this paper, we will use a framework to improve customer satisfaction with improved quality using Six Sigma technique. We hypothesize that using Six Sigma framework to reduce the defect rates. Therefore, we demonstrate the savings that are possible by using this framework for reducing DPMO on products in this paper. A case study will be given in this paper to prove the efficiency gains after using these techniques.

Key words:

Six Sigma, DPMO, Z value, simulation model, Markovian chain.

1. Introduction:

If the company wants to enhance its competitive advantage in the face of increasing globalization, one good way is to consider moving certain operations to China. If companies are considering outsourcing products to China because of cost, that's a good choice because the cost saving could improve competitiveness for companies in the US market. Sourcing from China would minimize your manufacturing cost for very competitive prices. US companies don't need to build a factory or manufacturer, and instead places more emphasis on product performance and manufacturing cost-effectiveness. All of the advantages of low factory makeup that will add value to US companies. That's why so many US companies choose working with Chinese manufacturers for increasing profits.

Even though several other reasons can be listed up in favor of outsourcing, one must not overlook the disadvantages of it. Typically, the argument from the company's perspective is that bad quality in developing countries like India, Southeast Asia, China, etc., harms the goal of producing products for satisfying the specifications of greater quality. As we know, the costs of poor quality are huge. Two examples of such costs are added expense and lost customers. Therefore, the critical issue is that manufacturing cutting costs wherever possible while improving the quality of products as much as possible.

Note, if a company wants to source products from Chinese manufactures, they began taking their jobs by offering a cheaper product of equal quality. “A recent survey of 145 U.S. companies by Forrester Research found that 88 percent of the firms that look overseas for services claimed to get better value for their money offshore than from U.S. providers, while 71 percent said offshore workers did better quality work. But that does not mean the quality of product from China is good enough: companies want more assurance on their products' quality consistency. Companies strive to delight their customers and relentlessly look for new ways to exceed their expectations”.

So, exceptional quality track records are made standard for suppliers' specifications on quality from their customer. Six Sigma techniques are good ways to track records from Chinese manufacturers with quality inspecting. At the same time, Six Sigma is a highly disciplined process that helps us focus on developing and delivering near-perfect products and services. The concentrated idea behind Six Sigma is that if you can measure how many "defects" you have in a process, you can systematically figure out how to eliminate them. In this paper, there are frameworks that can be used to improve quality in Chinese manufacturing. Six Sigma techniques were used to develop these frameworks.

2. Problem statement:

Implementing Six Sigma on quality-control requires us to look at the business from the customer's perspective. In other words, we must look at our processes from the outside-in. By understanding the product lifecycle from the customer's needs and processes, we can discover what they are seeking and hoping. With this knowledge, we can identify areas where we can add significant value or improvement from their perspective. SIPOC technique is a tool used by a process improvement team to identify all relevant elements of a process improvement project before work begins. The tool name prompts the team to consider the Suppliers (the 'S' in SIPOC) of your process, the Inputs (the 'I') to the process, the Process (the 'P') your team is improving, the Outputs (the 'O') of the process, and the Customers (the 'C') that receive the process outputs. A further explanation is presented here along with a concrete company in US which wants to outsource from a Chinese manufacturer.

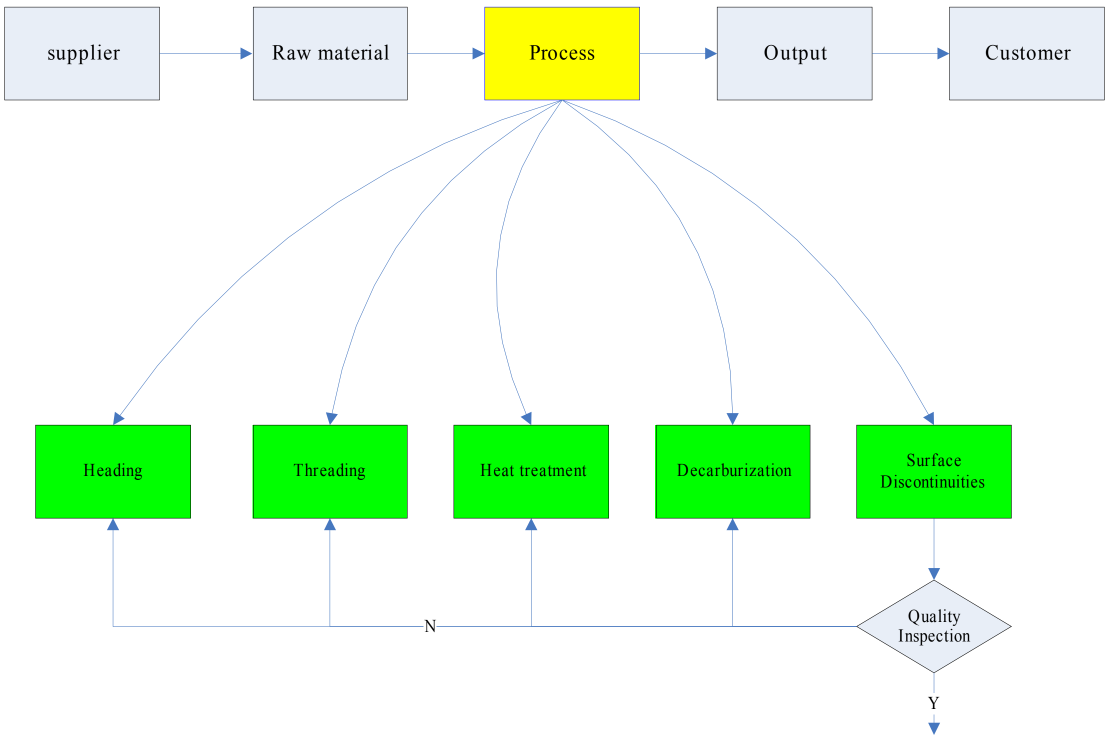

Figure 1. SIPOC Diagram

The whole process of Chinese suppliers to US companies is started from raw material brought by Chinese manufacturers to the final product delivered to customer. We can capture some understanding on material and product flow in SIPOC by taking into account not only the activity of the product, but also the management and information systems that support the basic process.

3. Case statement

We hypothesize using Six Sigma framework that will reduce the DPMO defect rate in Chinese manufacturer. We focus on the working procedure in producing bolts that is presented in "process" in SIPOC diagram (Fig.1). A case we use is a Chinese manufacturer which produces qualified bolts as a supplier for US Company. The main problem related to the Chinese manufacturer is inconsistency in quality of their product—bolts. That means, the customer's specification can not be satisfied for the bad quality of bolts, and they must pay additional cost on quality inspection and always need to engage in management consultancy, impartial inspection and other quality & technology services in China. That would be the extra responsibility in front of US companies if you want to outsource parts or product from China.

3.1. DPMO

The risk of receiving poor quality goods will appear in inspection measurements; 1. Plant Evaluation. 2. Pre-production Inspection (PPI). 3. During Production Inspection (DPI). 4. Final Random Inspection (FRI). 5. Supervision of Loading into container. Therefore, the

US Company wants the inspection data such as DPMO to their expectation at least in the lowest level from FRI. To take the Chinese manufacturer for example, it could get some "bad news" from figure 2.

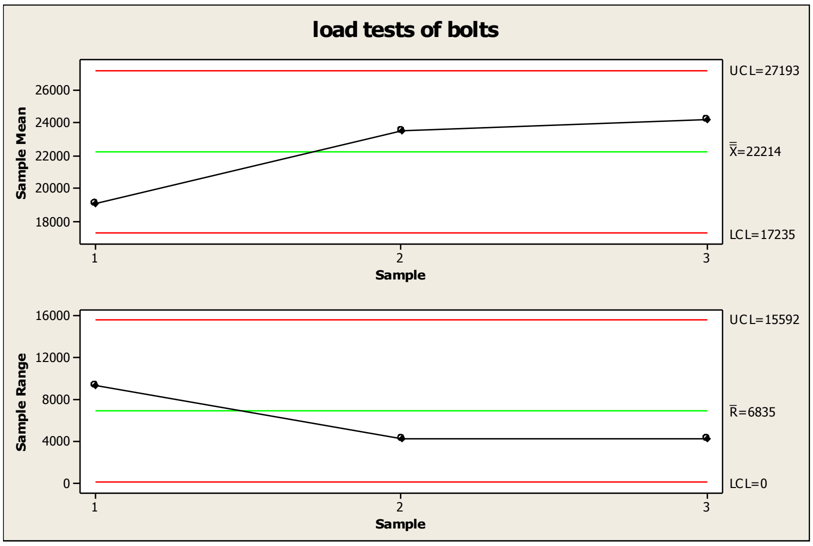

Figure 2. FRI on samples

Two subgroups of samples were conducted in the final load test which made in different period and different batches. The index we have is DPU, and we could get the value of DPMO from the equation below:

$$DPMO=DPU \times 1{,}000{,}000 \quad \textbf{(1)}$$

So, the DPMO for the defect of bolts is 13800, that's the terrible number for the customer —the US company. The reason for the high DPMO rate is because the quality of two batches of products is not consistent enough to sustain to the expected level.

The x mean chart and R chart of the data shown in Figure 3 indicates that the process is in control.

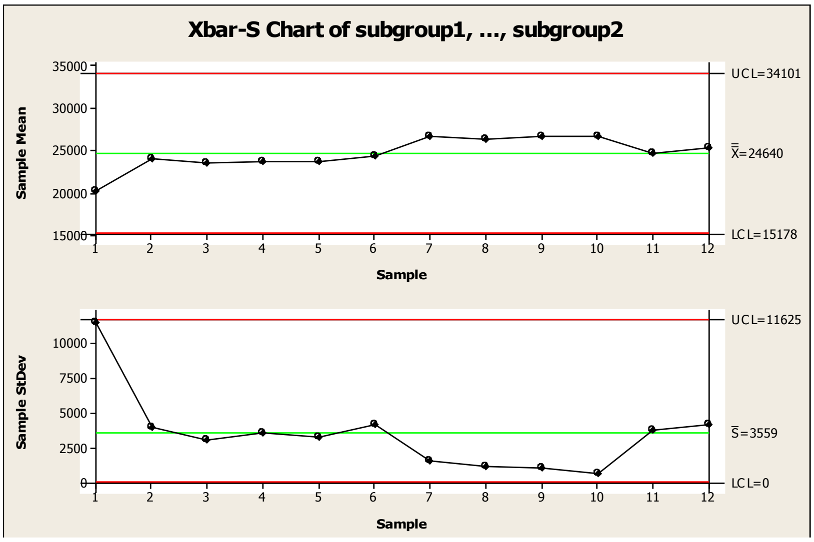

Figure3. Process in control

3.2. Z value

Z value is a measure of the distance in standard deviations of a sample from the mean. Each process sigma has two equivalent values which provide a meaningful way to compare data and understand how defective a process is.

Testing was carried out per the requirements in SAE J429 section 6.5 for axial tensile strength determination. The specification on Grade 8 bolts (customer requirements) fine thread must meet a minimum load of 24,000 lbs before fracture.

The standard deviation estimate is

$$\sigma = \frac{\sqrt{\sum_{i-1}^{n} \left(xi - \bar{x}\right)^2}}{n - 1} \qquad \textbf{(2)}$$

The data were presented as a control chart in figure 4. The procedure used to calculate process capability/performance indices is described below. We will use the specification limits (there is only one specification limit).

- Lower: 24,000 1bs
- Upper: none

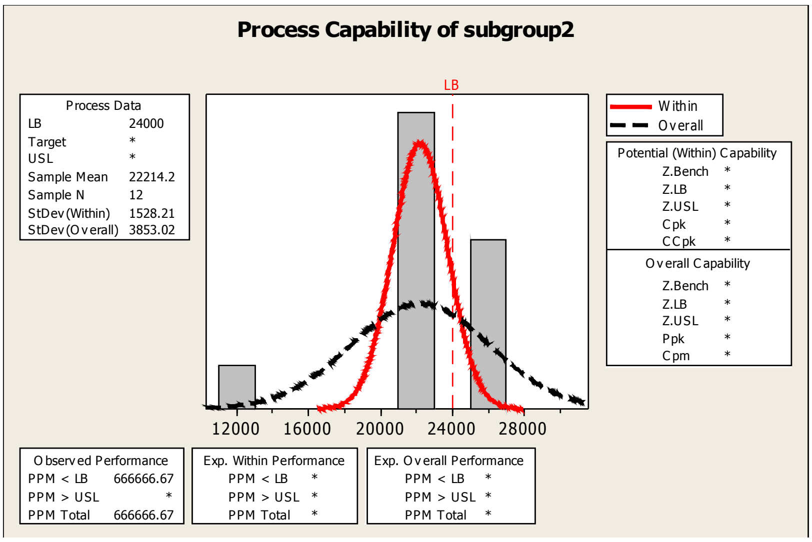

Figure 4. Control chart

We could calculate the Z value within the sample batches, and make a prediction on real world cases for forecasting the quality level on process control.

$$Z_{LT} = \left| \frac{\overline{X} - LSL}{S} \right| = 0.17 \qquad \textbf{(3)}$$

The value of Z equals to:

$$Z_{LT} = -\widehat{LSL} / S$$

The current Z value equals to 6.743. Theoretically, the shift Z value equals to 8.243 which calculated by the equation $Z_{ST} = Z_{LT} + 1.5$

4. Hypothesis statement.

One of the hypotheses in this paper is Z value after using Six Sigma will be larger the than the Z value before Six Sigma. We will use two values and build hypotheses on each of quality level before and after using Six Sigma technique. (Framework) The hypothesis statement is:

$$H_0 : Z_{ST} = Z_A$$
$$H_1 : Z_{ST} \neq Z_A$$

Note: Z_A : Z value after implementing Six Sigma

5. Markov model description.

To obtain very accurate and detailed simulation model, one has to represent many realistic features, which is possible with mathematical models.

5.1 Markov model statement

The Integrated manufacture process has led to the development of a unified test bed which built for manufacturing functions: manufacture, assembly control, and order acquisition, resource management, scheduling and producing. These tests rely on ontology for activity, state, time, resources, cost, quality and organization.

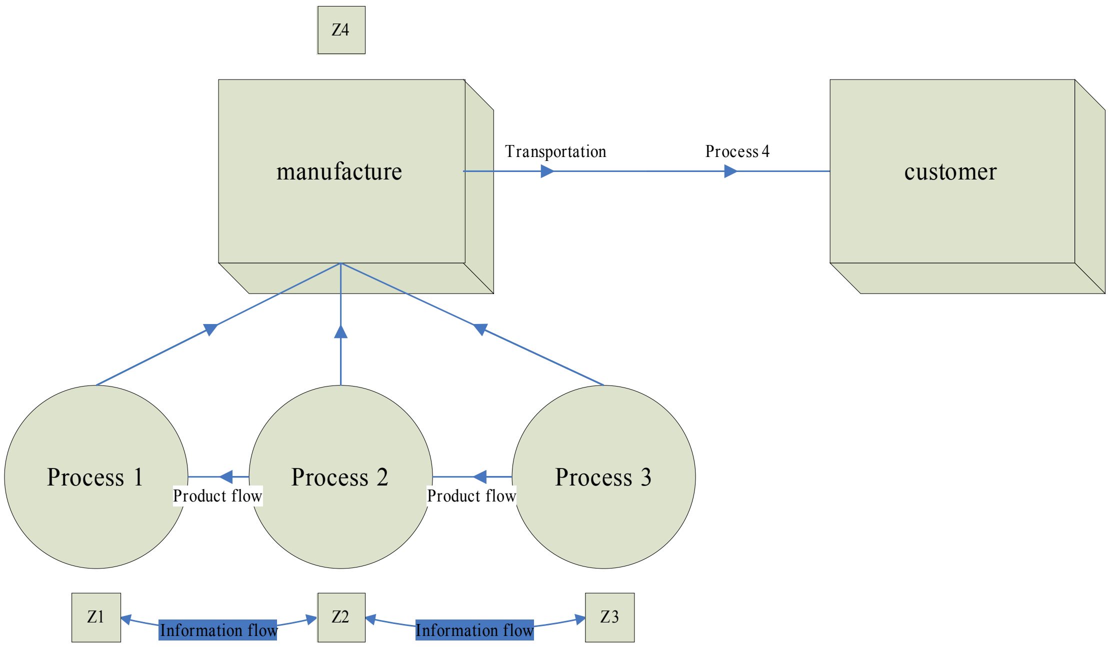

Figure 5 flow chart

Vendors and manufacturers weigh every Z value complies with the DPI and FRI within the product flow. Fig5 show us the information and product or material flow from manufacture to customer, we define the information flow in Z and it is the same meaning as the Z value for inspection results, and the equation defined as:

$$y_{ZB} = Ax_{Z1} + Bx_{Z2} + Cx_{Z3} + Dx_{Z4} + \varepsilon \qquad \textbf{(5)}$$

for $\sum_{n=1}^{4} Z \Rightarrow Z_B$

Those four variables in four different processes influence the outcome of the process, at the same time; they influence each other as well. Now assume that while Z is in state

$k \subset (1,2,3,4)$, the probability of y_{ZB} is completely determined by Z_k, and this holds for every $1 \leq k \leq 4$. Note that when Z undergoes a transition to, the probability for Z_k is modulated by the state of k.

	DPU	DPMO	Z value
P1/ X_{Z1}	**2.11%**	**21100**	**-.823**
P2/ X_{Z2}	**1.14%**	**11400**	**3.244**
P3/ X_{Z3}	**.43%**	**4300**	**4.118**
P4/ X_{Z4}	**1.38%**	**13800**	**6.743**

Table1. The inspection data for DPMO

5.2 Stochastic fluid flow system for discrete manufacturer process

A stochastic fluid flow system is an input-output system where the input is modeled as a continuous fluid that enters and leaves a storage device, called a buffer, according to randomly varying rates. Such models are motivated as approximations to discrete queuing models of manufacturing systems, high-speed data networks, etc. the main purpose of this part is to provide a general framework for a variety of fluid models that have been studied in the literature. The customer, vendor, Chinese manufacturer and raw material supplier are in the chain where the external environment is a continuous time Markovian chain using data communication networks by order or product flow (Fig 6). Consider the equation (5), a

Markov process $M = \{M(t)\}_{t=0}^{\infty}$ with a discrete state space. In this case, M behaves as follows: it stays in a state i for and exponentially distributed holding time with parameter λ_i which depends on i alone; it then jumps to state j with probability p_{ij}. In a simple Markov traffic model, each jump of the Markov process is interpreted as signaling an arrival, so inter-arrival times are exponential, their rate parameter depending on the state from which the jump occurred. Their rate parameter depending on the state from which the jump occurred.

Markov models can be defined for the process $\{A_n\}$ in terms of a Markov transition matrix P = [p_{ij}] (6). Here, state i corresponds to separating successive arrivals, and p_{ij} is the probability of a j slot separation, given that the previous one was an i slot separation. Batch may themselves be described by a Markov chain, whereas continuous-state, discrete Markov processes can model the workload arriving synchronously at the system.

We have found that the every factor in the manufacturer process and the successive arrivals are distributed in the final model. Therefore, we consider a solution of the general Markovian queue which is exponentially distributed.

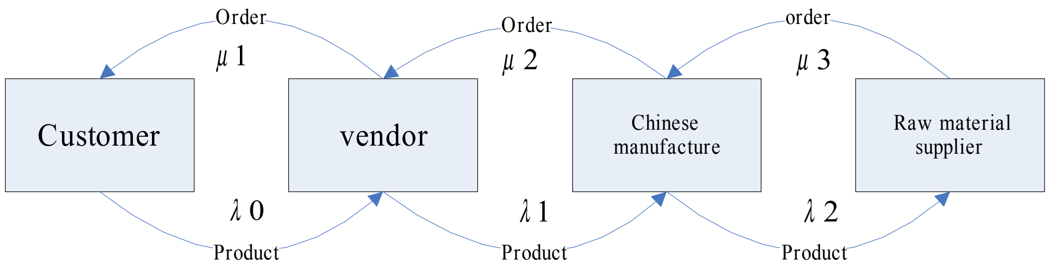

Figure 6 manufacturer transition diagram

We define that the qualified product rate as P in transition process, thus, the defect rate in process is q=1-P, when $\lambda n = i$ is known, the probability of state of λ_{n+1} only has an effect on λn. So, the probability equation as below is:

$$p_{ij} = P\{\lambda_{n+1} = j \ / \lambda_n = i\} = \begin{cases} p, j=i, \\ q, j \neq i \end{cases} \quad \text{i, j=0,1} \qquad \textbf{(6)}$$

The inspection results data are transformed from actual circumstance quality inspection results from FRI which was conducted by a vendor agent (See Appendix). The inspection results were transformed for transition matrix which composed by every single cell 1 and 0.

$n_{ij} = \begin{cases} 1, j=i \\ 0, j \neq i \end{cases}$, represents the average number of periods the unit will require for transition from s_i to s_j.

$$P = \begin{bmatrix} I & 0 \\ R & Q \end{bmatrix} = \left[\begin{array}{cccc|cccc} 1 & 0 & & 0 & 0 & 0 & & 0 \\ 0 & 1 & & 0 & 0 & 0 & & 0 \\ 0 & 0 & \cdots & 0 & 0 & 0 & \cdots & 0 \\ 0 & 0 & & 1 & 0 & 0 & & 0 \\ \hline S_{ij} & S_{ij} & & S_{ij} & S_p & S_p & & S_p \\ S_{ij} & S_{ij} & & S_{ij} & S_p & S_p & & S_p \\ S_{ij} & S_{ij} & \cdots & S_{ij} & S_p & S_p & \cdots & S_p \\ S_{ij} & S_{ij} & & S_{ij} & S_p & S_p & & S_p \end{array}\right]$$

Figure7. Transition matrix

From the equation above, we could get the transition point on defect and qualified products, so the probability of transition when λn is random could be calculated to discover the weak point in the manufacturing process.

6. Conclusion:

Although we have discussed simulation model of quality control in the manufacture process only, simulation is a powerful tool for solving many kinds of complex problems from the systematic perspective. Find out the relationship between factors and outcome. Models have also been used for scheduling, management, resource allocation, financial modeling.

The theory of Six Sigma in manufacture process influences the decision making in management from material supplier selection to customer feedback. Especially in quality control department, the techniques used in Chinese manufacturer are the first step in reducing

DPMO based on the actual circumstances. Additionally, the Markovian model combined with manufacturer process could be extended to supply chain issues.

Appendix

Samp_NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Subgroup1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	1	1	1	1	0	1
Subgroup2	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	1	1	1

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