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TECHNOLOGY - THE ULTIMATE SOLUTION IN SIX SIGMA

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Abstract

This paper aims at discussion on the impact of technology on 6 Sigma in controlling dispersion in data of a parameter, number of defective products produced and precision under consideration. Process natural variability and process off centering control are the major areas of focus for improvement through technology. Technology is the only last resort to adopt when all other options in 6M-Sigma and 6T-Sigma had already been maximized.

6M-Sigma (Metrics), as one of the statistical tool, is used to show the dispersion in data of an observing parameter on a Normal Distribution Curve. The design specification limits of a product can be considered as the goalposts that overlay NDC, in which the included population is considered as quality products. However, another quality phenomenon, called 'precision' is affected when more dispersion in data of a parameter of a product is allowed.

On the other hand, 6T-Sigma (Technique) represents a structured methodology which uses different qualitative and quantitative tools and technique of TQM for collection and analysis of information to improve process control, thus enhance quality and productivity.

When improvements through 6M-sigma and 6T-sigma technique reaches its maximum values and further progress becomes impossible, a breakthrough is provided by incorporating the technology option. This is a strategic decision and the only last resort to improve process natural variability. The technology option is kept at last as it requires capital investment through top management endorsement. The main objective of technology induction and indigenization is to meet the contradicting requirements of low rejection, low cost but high precision, high process capability and enhanced productivity.

The paper also highlights the Government of Pakistan’s Vision, Objectives, Strategies, Instruments and Action Plan focused only on technology are presented in the national ‘Technology Policy and Technology Development Action Plan of 1993’. MOST is the custodian of this national document. This document depicts the vital national approach for the best use of international and indigenous technology to improve the quality of life of all Pakistanis. Other organizations are also working on technologies relevant to their sector of industry, may be some overlapping. However, its full implementation is a big challenge to meet. There is an urgent need to have one central organization to look after all affairs of technology.
Introduction

The discussion focused here is on the impact of technology on process natural variability control and capability and its role in 6 Sigma arena of dispersion in data of a parameter, number of defective products produced, precision and process control under consideration. Technology is the only last option to adopt when all other tools and techniques in 6M-sigma (metrics) and 6T-sigma (technique) had already been optimized. Tarek (1999, p.1) has asserted that “technology can be defined as all the knowledge, products, processes, tools, methods and systems employed in the creation of goods or in providing service”. Tarek (1999, p.2) has also identified the three important components of technology as;

- **Hardware;** the physical structure and logical layout of the equipment or machinery that is used to carry out the required tasks.
- **Software;** the knowledge of how to use the hardware in order to carry out the required tasks.
- **Brain ware;** the reason for using the technology in a particular way."

Here, the focus of discuss is on hardware aspect of technology only as it can reduce the processes natural variability and process of centering.

Design specifications and process capability are the major areas affected by technology consideration. 6-Sigma (metrics), as one of the statistical tool, is used to show the dispersion in data of an observing parameter on a Normal Distribution Curve (NDC). The design specification limits can be considered as the goalposts overlay on NDC in which the included population is considered as passed quality products. As the values of design specifications increases on NDC, the goalposts get wider opened and more dispersed data of a parameter of a product is accommodated between its posts. This will show reduction in the rejection rate, which is outside the specification limits, hence increases productivity (Rawoof, 1999).

However, another quality phenomenon called ‘precision’ of product is affected when more dispersion in upper and lower specification limits of a parameter of a product is allowed. Also, process capability index will decrease when design specifications (dispersion) increases. Here comes the technology for rescue to reduce the processes natural variability and process of centering.

On the other side, 6-Sigma (technique) represents a structured methodology to use different qualitative and quantitative tools and technique of TQM philosophy for collection and analysis of information to improve process control, thus enhance quality and productivity.

When 6-sigma (metrics) and 6-Sigma (technique) reaches its optimum values and further improvements become impossible, a breakthrough is provided by incorporating the technology option. Technology is the last and the only resort to improve process natural variability. The technology option requires capital investment but is the only way to start improvement at new heights. The objective of technology is to meet the contradicting requirements of low rejection, low cost but high precision and enhanced productivity.

Only use and economics can provide a choice for decision makers among 6M-Sigma, 6T-Sigma and technology. Also, the main consideration should not be forgotten, that is, who are the customers? What are their requirements and how economically it can be met?
DESIGN SPECIFICATIONS

- **Limits**

These are the two extreme permissible value limits for parameters. The upper limit for a parameter is the largest value permitted for that particular variable and the lower limit for a parameter is the smallest value permitted for that parameter. The limits of value for a parameter are derived from the combination of the design value with the limits of tolerance.

- **Tolerance**

The tolerance on a parameter is the margin of error allowed on it for reasonable inaccuracy in workmanship and appliances. It is the total permitted variation in the actual value of that parameter. The difference between the two limits of value (Upper Tolerance Limit, UTL and Lower Tolerance Limit, LTL) for a parameter gives the tolerance. The greater the tolerances that can be allowed, the more cheaply can the work be produced.

- **Accuracy**

Accuracy is defined as the closeness of agreement between an observed value and an accepted reference value or standard. The lack of accuracy reflects a systematic bias in the measurement such as a gauge out of calibration, worn, or used improperly by the operator. Accuracy is measured as the amount of error in a measurement in proportion to the total size of the measurement. One measurement is more accurate than another if it has a smaller relative error (Evans & Lindsay, 1999).

- **Precision**

Precision, or repeatability, is defined as the closeness of agreement between randomly selected individual measurements or results. Precision, therefore, relates to the variance of repeated measurements. A measuring instrument with a low variance is more precise than another having a higher variance. Low precision is due to random variation that is built into the instrument, such as friction among its parts. This random variation may be the result of a poor design or lack of maintenance. Random errors are also associated with human participation in the measurement process. Examples include variation in the set up, imprecise reading of scale, round off approximation and so on. Good precision mean that random errors in the measurement procedure are minimized (Evans & Lindsay, 1999 & Groover, 1996).

6-SIGMA QUALITY

The term Sigma (also written σ, using the lower case Greek letter for Sigma), refers to the number of standard deviations away from the mean (or average) point in a bell curve, also known as a NDC. The bell shape curve (NDC) is a natural phenomenon experienced in large populations of almost anything.

If a million people are measured, only 3-4 people will fall in the very largest category - beyond UTL (6-Sigma from the mean) and only 3 - 4 people will fall into the smallest category - below LTL (6-Sigma from the mean in the other direction). The size of all the other people will fall into a ‘normal distribution’ as defined by the bell curve (Henderson & Larco, 1999) shown in Figure 1.

Levinson & Rerick (2002 p. 85) call the 6 - Sigma process capability as “The word 6- Sigma refers to six standard deviations between mean and the specification limit”, which basically refers to the 6 - Sigma (metrics) measurement on NDC.
As 6-Sigma (metrics) values go from $\pm 1 \sigma$ to $\pm 2 \sigma$ to $\pm 3 \sigma$, the dispersion in data increases.

As the design specifications (goalposts) widen, the number of defective products (outside the goalposts) decreases but quality (precision) decreases, that is, variation and dispersion in data increase. So, the $\pm 3 \sigma$ (metrics) does not give high precision (good quality). However, it does mean low number of defective products, thus high productivity. This phenomenon is shown in Figure 1. The most undesirable aspects in this curve is the widening of design specification limits (greater difference between LTL and UTL) causing more dispersion in data to accommodate.

![Figure 1: Wider goalposts (high dispersion and low precision but enhance productivity)](image)

As the process variability increases (data disperses from $\pm 1\sigma$ to $\pm 2\sigma$ to $\pm 3\sigma$) and the central tendency (precision) decreases as shown in Figure 2.

![Figure 2. Data Dispersion versus Central Tendency](image)

The ultimate aim is to get high precision, low tolerance and less dispersion. This will ultimately lead to more central tendency of a single pole scenario ($\sigma = 0$). This phenomenon is discussed in more details under process capability index (process variability control), for which upgradation of technology (machinery and equipment) is the only options available.

### 6 - SIGMA (METRICS) VERSUS 6-SIGMA (TECHNIQUE)

The aim of this discussion is to avoid confusion in the issue of title of 6 - Sigma for the readers and implementers. Writing only 6 - Sigma does not differentiate between the two concepts till complete study of the text. Also this title may develop different meanings when used or written by some one and understood by another with different frame of reference or context. A clear distinction is required between the two different types of Sigma.

- 6-Sigma (Metrics)
**6-Sigma (metrics)** is a statistical tool used on NDC. 6-Sigma (metrics) just measures the dispersion on NDC. In simple words, as the value of sigma increases, dispersion increase, so precision decreases. The point to be focused, debated and discussed over here is to have a complete understanding of the different parameters of a product, their design specification and measurements of dispersion. An integrated view of the impact of 6-Sigma (metrics) is needed rather than its isolated aspects, such as, the number of defectives products, precision in parameters, cost, productivity and the trade off among them at the points of interest. For example, high precision and low dispersion ($\sigma$) requires high technology for its production, high-tech instrumentations for its measurements and skilled workforce for its use. Also, more precision requires closed limits, tolerances and allowances. However, this will increase the cost effect but enhance quality. It may also increase rejection rate (products outside the goalposts of design specification limits) of production. 6-Sigma (metrics) increase data variability, wider design specifications (goal posts), increases productivity and reduces rejection but decrease precision.

- **6-Sigma (Technique)**

6-Sigma (Technique), as a structured methodology, uses a number of qualitative as well as quantitative tools and techniques of TQM philosophy. 6-Sigma title gains its popularity when brought under the umbrella of competitive business philosophy of TQM. 6-Sigma (techniques) improves both quality and quantity (productivity through process improvement and control. Failure Mode and Effect Analysis, Statistical Process Control, Process Mapping, New Management Tools, Descriptive Statistics, Hypothesis of Testing, ANOVA, Sampling, Measurement System Analysis, 7 Tools of Quality, Advanced analysis tools (Design of Experiment, Linear Regression, etc.), Re-engineering, Lean manufacturing, Supply chain improvements, Design for Six Sigma (DFSS) for development of new products, new services, new processes, and new workflows are some of the major initiatives used under 6-Sigma technique.

The titles of 6-Sigma champions or mentors (as strategy providers), Black Belts (as team leader) and Green Belts (as implementers) are used for process improvement and control in 6-Sigma (technique). 6 Sigma (technique) reduces the process control (off centre-$\mu$), thus decreases rejection. Hence, more population of products comes within the specification limits. As such the rejection rate drop and the company competitive level of quality enhances in the world market but it can not control process natural variability.

Care must be taken in writing the two titles of sigma differently, say 6 - Sigma (metrics) as 6M-Sigma and 6-Sigma (Technique) as 6T-Sigma.

**Implementation Methodology of 6t-Sigma (Technique)**

There are no new tools and techniques in 6-Sigma (technique) that have not been used earlier in TQM philosophy. However, 6-Sigma (technique), an integrated and structured methodology is used in a logical sequence for collection and analysis of information, thus, reducing process off centre control ($\mu$), solving any problems or carrying out improvement of any functions.

Both Motorola and General Electric was the beneficiary of 6-Sigma methodologies. GE used a four-phase approach for implementation as follows:

- **Measure**: Select critical quality characteristics, determine the frequency of defects, define performance standards, validate the measurement system, and establish product capability.
- **Analyze**: Understand when, where, and why defects occur by defining performance objectives and sources of variation.
• **Improve:** Identify potential causes, discover cause-effect relationships, and establish operating tolerances.

• **Control:** Maintain improvements by validating the measurement system, determining process capability, and implementing process control systems (Evans & Lindsay, 1999 & Rawoof, 1999).

Levinson & Rerick (2002) state about implementation of 6-Sigma technique as “6-Sigma refers not only to the process capability, but to the quality and productivity improvement programme as described by Harry and Schroeder (2002). Harry and Schroeder add quality improvement and problem-solving tools to the Six-Sigma umbrella. These activities rely on the standard PDCA improvement cycle, or it rough equivalent, Define, Measure, Analyze, Improve, Control (DMAIC). Harry and Schroeder extend DMAIC to an eight-step process; Recognize, Define, Measure, Analyze, Improve, Control, Standardize and Integrate”.

**Process Capability**

Process Capability is important to both product designers and manufacturers. Knowing process capability allows one to predict, quantitatively, how well a process will meet design specifications (LTL and UTL) and to specify equipment requirements (to control process natural variation - \( \sigma \)) and the level of process control (off centre - \( \mu \)) necessary. For example, if a process is not capable of meeting the design specifications of a product or service, then management faces three possible decisions; (1) Change the design specifications, (2) Measure each piece of production and either re-do the process or scrap nonconforming parts, or (3) Develop a better process by investing in new technology. These options are further elaborated as follows:

- Changes in design specifications may sacrifice fitness for use requirements and result in lower quality (precision) products.
- Scrap and rework are poor strategies, since labor and materials have already been invested in a bad product or service. Also, inspection errors will probably allow some nonconforming products to leave the production facility.
- **The technology option (modification or new)** might require substantial investment, which the firm may not be able to afford. Thus, these factors demonstrate the need to consider process capability in product design and acceptance of new contracts (new design specifications). Many firms now require process capability data from their suppliers. Product design should not be carried out in isolation but keep in mind the process capability to follow the concept of ‘Design For Manufacturing (DFM)’ (Evans and Lindsay, 1999).

Process capability has three important components; (1) the design specifications (LTL and UTL) (2) the processes control by centering (\( \mu \)) of process natural variation and (3) the range, or spread of variation (\( \sigma \)) as shown in Figure 3.

![Figure 3. Components of Process Capability](image-url)
There are four possible outcomes that can arise when process natural variability ($\sigma$) is compared with design specifications (LTL and UTL) as shown in Figure 4. In Figure 4a, the design specifications are looser than the process natural variation; one would expect that the process will always produce conforming products as long as it remains in control (not off centered $\mu = 0$). It may even be possible to reduce costs by investing in a cheaper technology that allows for a larger variation in the process output ($\sigma$).

In Figure 4b, the process natural variation and design specifications are the same. A small percentage of nonconforming products might be produced; thus, the process should be closely monitored.

In Figure 4c, the range of process natural variability is larger than the design specification; thus, the current process could not meet design specifications, even when it is in control (centered $\mu = 0$). If the process is in control but cannot produce according to the design specifications, the question should be raised whether the specifications have been correctly applied or if they may be relaxed without adversely affecting the assembly or use of the product. If the specification are realistic, an effort must be made to improve the process (reduce $\sigma$ by upgrading equipment) to the point where it is capable of producing consistently within design specifications. Finally, in Figure 4d, the process capability is the same as in Figure 4b, but the process average is off-centered ($\mu$ is not zero) due to tool wear, machine set up, new batches of material etc (Rawoof, 1999). This is also a partial technology problem which usually can be corrected by a simple adjustment of a machine setting or recalibrating the inspection equipment used to capture the measurements. If no action is taken, however, a substantial portion of output will fall outside the design specification limit even though the process has the inherent capability ($\sigma$) to meet the design specifications (Evans & Lindsay, 1999).

**Figure 4 Design Specifications against Process Natural Variability ($\sigma$)**

![Figure 4](image_url)
Process Capability Indexes

The process capability index $C_p$ is defined as the ratio of the design specification width to the natural tolerance ($6\sigma$) of the process in a single quantitative measure.

$$C_p = \frac{\text{Design Specification}}{\text{Natural Process Variation}} = \frac{\text{Design Limits (LTL & UTL)}}{6\sigma} = \frac{\text{LTL} - \text{UTL}}{6\sigma}$$

Suppose that a process has a standard deviation ($\sigma$) of 1 and a tolerance spread (LTL-UTL) of 8, and then the value of $C_p$ is 1.33. Now keep the tolerance limits constants (8) (no change in design specification) and decrease standard deviation - $\sigma$ (reduce the process natural variability which is only possible through acquisition of emerging technology of highest precision), so $C_p$ will increase as shown in Table 1.

<table>
<thead>
<tr>
<th>LTL - UTL (Constant)</th>
<th>$\sigma$ (Reduce)</th>
<th>$6\sigma$ (Reduce)</th>
<th>$C_p$ (Improve)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>1</td>
<td>6</td>
<td>1.33</td>
</tr>
<tr>
<td>8</td>
<td>0.8</td>
<td>4.8</td>
<td>1.66</td>
</tr>
<tr>
<td>8</td>
<td>0.67</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>8</td>
<td>0.44</td>
<td>2.67</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Table 1. Improve Process Capability Index ($C_p$) by Reducing Process variation ($\sigma$)

This task involves reducing the variability in the process (standard deviation $\sigma$) using process improvement and minor equipment upgrades.

This discussion assumed that the process was centered ($\mu = 0$); clearly the value of $C_p$ does not depend on the mean ($\mu$) of the process. To include information on process centering, one-sided indexes are often used. One-sided process capability indexes are as follows:

$$C_{pl} = \frac{\mu - \text{LTL}}{3\sigma} \quad (\text{lower one-sided index}) \quad C_{pu} = \frac{\text{UTL} - \mu}{3\sigma} \quad (\text{upper one-sided index})$$

$$C_{pk} = \min (C_{pl}, C_{pu})$$

To illustrate these computations for any product, suppose a mean ($\mu$) of 10.7171, design specification of 10.75+ .25 and process variation ($\sigma$) = 0.0868

Thus,

$$C_{pl} = \frac{10.7171 - 10.50}{3 \times 0.0868} = .83 \quad C_{pu} = \frac{11.0 - 10.7171}{3 \times 0.0868} = 1.086$$

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\[ C_{pk} = \min \{0.83, 1.086\} = 0.83 \]

Here the process is more capable of satisfying the upper design specification limit than the lower design specification limit. The low value of \( C_{pk} \) indicates that the worst case is unacceptable. This index is often used in specifying quality requirements in purchasing contracts.

Process capability indexes depend on the assumption that the distribution of output is normally distributed. This is not the case when output is affected by tool wear and exhibits a highly skewed distribution, process capability indexes can be below 1 even though all measurements are within specification limits. Higher process variability (more deviation or spread - \( \sigma \)) and products out of specifications (\( \mu \) is more off centered) are the main reasons of customer dissatisfaction (Evans & Lindsay, 1999).

Different combinations of \( \mu \) and \( \sigma \) are found in Table 2, which shows the number of non conformance per million for different levels of quality and different levels of off centering (Evans & Lindsay, 1999). In many cases, controlling the process off centering to the target is less expensive (only process control is improved) than reducing the process variability (\( \sigma \)). Technology is the consideration for solution of such partial problem (\( \mu \)) and total problem (\( \sigma \)) Table 2 can help to assess the trade-off as:

- Controlling the process off centering (\( \mu \)) by adjustment of existing equipment / re-calibration. This is a partial technology problem.
- Reducing the process variability (\( \sigma \)) by improvement of processes or upgrading technology. This is a total technology problem.

<table>
<thead>
<tr>
<th>Quality Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-Centering (( \mu ))</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0.25 Sigma</td>
</tr>
<tr>
<td>0.5 Sigma</td>
</tr>
<tr>
<td>0.75 Sigma</td>
</tr>
<tr>
<td>1 Sigma</td>
</tr>
<tr>
<td>1.25 Sigma</td>
</tr>
<tr>
<td>1.5 Sigma</td>
</tr>
<tr>
<td>1.75 Sigma</td>
</tr>
<tr>
<td>2 Sigma</td>
</tr>
</tbody>
</table>

Table 2. The Number of Defectives (Parts per Million) for Specified Off-Centering of the Process and Quality Levels

All this discussion can be summarized and presented in a diagram as shown in Figure 5 (Evans & Landsay, 1999 & Rawoof, 1999). This figure is in fact an elaboration of Figure 3. Here the three options available are:-

- **Option 1** can be used to loose the design specifications (lowering precision) if not compromising on product’s function. However, tight design specifications (high precision) are desired from quality perspective.
- **Option 2** is possible through 6M-sigma methodology and should be followed to control and improve the process through different means available. Here, technology is partially associated in the form of tool
wear and calibration.

**Option 3** is mainly related to technology where process natural variability control is the main focus. This is only possible through technologies modification or up gradation. As such, technology is the last option to resolve the precision and productivity problem together. However, only capital availability and investment is the decision making point in this case.

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**The Vital Role Of Technology**

Technology plays a vital role in the production of quality and precision products and services. All the approaches mentioned here seems to be focusing on improvement and control of processes rather than its modification and replacement. The only option available, if further improvement is not possible with 6T-sigma methodology, is the adoption of technology. Technology is considered the only solution for such partial problem (μ) and total problem (σ). Technology is a strategic decision to be taken by the top management as it requires capital investment for up gradation or replacement of technology and equipment. As such, the only last resort after 6M- Sigma and 6T-sigma is technology option. This is a very significant option to become world class in quality production (high precision and more output) of products and services. Technology improves process natural variation, thus accommodating tight design specifications (low tolerances and high precision) (Tarek, 2000).

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**Six Sigma Technique And Technology In The Pakistani Perspective**

**Six Sigma Technique.** This technique is in its early stages in Pakistan as its training and adoption is in progress through different public and private sector organizations. As discussed earlier, such 6T-Sigma can control the off centering of the processes by adjustment and re-calibration of production machines and setting of equipment which can reduce the rejection rate to some extent. This technique also re-calibrates measuring instruments and gauges and uses better skills, but can not enhance the process capability and index. It is only possible through adoption of emerging technologies with highest precision, in-process compensation and quality control capability and improved index.

**Technology.** The Government of Pakistan's Vision, Objectives, Strategies,
Instruments and Action Plan focused only on technology, are presented in a major national document titled ‘Technology Policy and Technology Development Action Plan of 1993’ prepared by the Ministry of Science and Technology (MOST, 1993). This document depicts the vital national approach for the best use of international and indigenous technology to improve the quality of life of all Pakistanis. A few major aspects of this ‘Technology Policy’ document are reproduced in Annexure ‘A’ at the end of this paper.

There are a number of public sector organizations working on international and indigenous technologies (www.most.gov.pk), like, Pakistan Council for Renewable Energy Technologies (PCRET) which was developed through merging of Pakistan Council of Appropriate Technology (PCAT), National Institution of Silicon Technology (NIST) and Solar Energy Research Council (SERC). Chief Technology of Pakistan Council of Science and Technology (PCST) has also constituted different experts committees to prepare comprehensive technology report in which ‘Engineering and Manufacturing Report’ is focusing production technologies. Also, Pakistan Council of Scientific and Industrial Research (PCSIR) is another organization closely linked to the industry for new products development and technology indigenization. The latest addition in the list of organizations is the Pakistan Technology Board (PTB) which is in the process of formulation. This organization is working on a project of national technology foresight to identify technologies and their priorities for different industrial sectors. There is another organization called Pakistan Scientific and Technological Information Centre (PASTIC) (www.pastic.gov.pk) which provide information-base services about technology upgrading for different businesses in a few specified sectors. The source of such information is mostly the industrialized countries.

One may get confused with such large number of organizations working on technology. There may be some working areas of overlapping as well. However, the main reason is the specialization of emerging technologies in each field and sector of manufacturing, production and service which is becoming more difficult for one organization to look after.

Pakistan could have gained advantages as late comer to invest in the latest technologies. However, this good intention was mostly hampered by slow and partial implementation due to low pace of deregulation, privatization and liberalization. Resultantly, it could not generate the desired exploitation of technology by all sectors of the economy at the national level. Isolated initiatives by some public and private sector businesses can not divert the technology advantages in their favor till the implementation at national level is more focused and prioritized.

In the recent past, the industrialized countries of the world have shifted their technology paradigm in order to give most of the manufacturing businesses to the developing economies while concentrating on service sector. Pakistan's regional competitors, like India, China, and Korea are taking full advantages of the opportunity. However, technology transfer and absorption in Pakistan is at a slow rate because of lack of research and development, less absorption capacity in the form of skills, maintenance, repair and less competitive use. This phenomenon has become more visible in the present era, which has shown relation with sluggish productivity, low GDP growth, higher rejection rate and higher production cost due to low precision and poor quality in manufacturing sector. This phenomenon will make the industry more vulnerable to the severe competition of world market.

Only emerging technologies can solve the problem of low precision, accuracy and productivity. Public and private sector should carry out its ‘technology audit’ to check the suitability of existing technology with present day requirements and its capability for meeting the incoming challenges under the World Trade Organization (WTO) protocols. MOST should also frequently review its technology vision, objectives, strategies, instruments and action plan due to faster world
technology dynamics and specialization. Solution in the form of establishing only one ‘National Technology Enquiry Point’ for policy formulation, information, coordination, indigenization and adaptation of technology is need of the hour.

Conclusion

To conclude with, this paper focused its main discussion on the impact of technology on 6-Sigma in dispersion of data of a parameter and the number of defectives products produced under consideration. It also differentiate between 6M-Sigma (metrics) and 6T-Sigma (techniques) used for collecting and analysis information to control and improve processes and solving problems. 6 Sigma can be abbreviated as 6M-Sigma and 6T-Sigma. Process capability index give a comparative analysis of design specifications against process natural variability.

Care must be taken not to ride on the bandwagon of 6-Sigma without knowing its basis, types, impact and points of trade off. Also, clear understanding of differences is required between 6M-Sigma (metrics) and 6T-Sigma (technique). Only 6-Sigma is not a panacea for all improvements and control of processes. Process natural variability control is out of its scope. As such, only technology, as a last resort, can be used for improvement of processes when all other options of partial technology had already been tested for its optimal values.

The Government of Pakistan’s ‘Technology Policy and Technology Development Action Plan of 1993’ presents its Vision, Objectives, Strategies, Instruments and Action Plan focused on technology only. This document depicts the vital national approach for the best use of international and indigenous technology to improve the quality of life of all Pakistanis. Other organizations are also working on technology relevant to their sector of industry. However, implementation is a big test to validate their policies.

ANNEXURE ‘A’

Vision

Pakistan must join the world economic community as member of the group of newly industrialized countries before the current century closes. The goal of the national technology policy is to help attain this vision by promoting the best use of international and indigenous technology in various sectors of economy and thereby accelerating economic growth and improving the quality of life of all Pakistanis.

Objectives

Four main objectives of the technology policy are:

• Bridge the gap between the best local and the best international practices in industrial technology.
• Bridge the gap between the best and substandard local practices in industrial technology.
• Improve and develop technology to enhance international competitiveness in the long run.
• Technical manpower development

To realize these objectives the ‘Technology Policy’ will adopt a pro-active role
Strategies guided by the following strategies.

- The technology policy envisages a leading role for the private sector. The role of the public sector is to the best that of a catalyst in creating a conducive environment for private sector initiative in industry, trade and investment.
- To enhance Pakistan’s reputation in the international market as a supplier of quality products and services, the policy will promote the development of a viable metrology, standards, testing and quality system.
- The policy will promote the development of an efficient R & D system responsive to both short and long term market needs.
- The policy will strengthen the channels for dissemination of technocommercial information.
- It will promote efficient technology transfer through liberalization of the regulations and through the promotion of direct foreign investment.
- The policy will promote technical manpower development in the country.
- The policy shall also target small and medium industry.
- The policy will promote environmentally sound and sustainable technologies.
- The policy will encourage use of informatics in the private and public sectors to promote efficiency and increase revenues.
- The policy will promote new and emerging technologies in material sciences, biotechnology, informatics and alternate resources of energy as these areas are going to become increasingly important in the future.
- The national technology policy will aim at harmonizing its recommendations with the national development plan and other related national policies.

Instruments To implement the strategies of the ‘Technology Policy’ the following instruments have been devised.

- A liberal regime for technology transfer and means to attract foreign investment.
- Effective mechanism for assessment, selection and induction of technologies.
- Rationalization of R & D system.
- Commercialization of R & D.
- Strengthening of industrial infrastructure.
- Framework for industrial extension.
- An effective metrology, standards, testing and quality system.
- Effective dissemination of techno-commercial information and information technology.
- Promotion of technical and vocational training.
- Financial support for technology development.
- Trade and tax policy as technology development instruments.
- Intellectual property right.
- New and emerging technology.
- Implementation mechanism.

Technology Development Technology Development Action Plan (TDAP) provides a framework for implementation of the National Technology Policy (NTP). It comprises the
Action Plan

following two parts:

• The Action Plan, which underlines specific policy actions and related projects, through which objectives of the NTP would be realized.
• Technology Development Plan, which gives a list of projects selected to support the NTP and the Action Plan. More projects will, however, be added to the list as and when received from remaining agencies.

References


MOST (November 1993). National Technology Policy and Technology Development Action Plan


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