

Opportunities and Implications of Six Sigma for Bangladeshi Industries: Case Study on a Cable Manufacturing Organization

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Abstract

The purpose of the paper is to illustrate the process of implementing Six Sigma in a cable manufacturing organization of Bangladesh. Major fundamental streams have been introduced to outline the concept of Six Sigma for Bangladeshi industries, and the related methodologies for the research and finally the sigma level of the organization is determined. Practicing Six Sigma could enable the company to eliminate a wide range of long standing process variation problem. This research had been undertaken to highlight the importance of a structured process and the importance data collection. Originally, it could be drawn attention to the managers on how Six Sigma can be used to enhance existing improvement efforts. Finally the specific practical example shows how the approach can be used to tackle long standing, and often hidden quality issues.

Index terms— Quality tool, Process capability, Six Sigma, Defect per million opportunities, Parts per million.

1 Introduction

Six Sigma is a business process improvement strategy which essentially checks what a business is doing, what its customers want, what can be most effective process and what variation could be removed from that process to provide significantly improved consistency. This approach is a modern method for quality management aimed at minimizing the number of defects in any process. It is a philosophy which, in achieving its strategic aims, provides such stability of the processes that the defects are only a few in a million (Breyfogle et al., 2000, and Galabova & Nenkova, 2003). The Six Sigma is a unique means of quality measurement, which can be applied irrespectively of the type, complexity and diversity of the processes and products. The attention is focused on the processes, as the final results depend on what happens during the processes (Galabova & Nenkova, 2005). Six Sigma's core philosophy focuses mainly reducing variability. It relies on the assumption that the output of every process should fall within acceptable limits (Carrigan & Kujawa, 2006).

Quality is specifically measured in terms of defect rates and is assessed from the customer's perspective. More formally, Six Sigma can be described as an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates (Linderman et al., 2003). The concept of Six Sigma was first introduced by MOTOROLA Inc. during the later part of 1980s. Motorola developed and vigorously pursued the Six Sigma quality program by attributing much of its quality improvement to this program (McFadden, 1993). Since then many other companies have developed their own six-sigma programs, including General Electric, Texas Instruments, Eastman, Kodak etc. Six Sigma concept helps measure the level of excellence in performance of any activity. This also measures the capability of the activity to perform defect free work. In fact, Six Sigma relies on normal distribution theory to predict defect rates of any activity being predicted. In addition to this, Six Sigma uses several statistical measures to analyze and interpret the data on processes and products. The best known of these measures is the Six Sigma goal of 3.4 parts per million opportunities or defects per million opportunities

44 (PPMO or DPMO) defect rate. Interestingly, Six Sigma has evolved over years and become a customer-driven
45 approach ??Ravichandran, 2010). Historically a process was considered to be capable if specifications were +/-
46 3 standard deviations from the mean, which would result in about 3 defects per thousand opportunities if the
47 process remained centered. Six Sigma follows a much more stringent approach to defining process capabilities,
48 and provides tools for mathematical computation of that capability. If a process is capable at six standard
49 deviations, only 3.4 defects per million opportunities would occur (assuming a 1.5 standard deviation shift in the
50 process mean) (Langabeer et al., 2009, andSung, 2003). Six Sigma is a highly disciplined approach to decision
51 making that helps people focus on improving process to make them as near perfect close to "zero defects" as
52 possible (Stevenson, 2009).

53 2 II.

54 3 Motivation Behind this Study

55 Six Sigma has become very popular throughout the whole world. There are several reasons for this popularity.
56 Many companies, which were not quite successful in implementing previous management strategies such as TQC
57 and TQM, are eager to introduce Six Sigma. It is viewed as a systematic, scientific, statistical and smarter (4s)
58 approach for management innovation which is quite suitable for use in a knowledge-based information society.
59 The essence of Six Sigma is the integration of four elements (customer, process, manpower and strategy) to
60 provide management innovation (Montgomery, 2009). Six Sigma provides a scientific and statistical basis for
61 quality assessment for all processes through measurement of quality levels. The six sigma methods allow us
62 to draw comparisons among all processes, and tell how good a process is. Through this information, top-level
63 management learns what path to follow to achieve process innovation, and customer satisfaction and to improve
64 quality and process capability. Second, six sigma provides efficient man power cultivation and utilization. It
65 employs a "belt system" in which the levels of mastery are classified as green belt, black belt, master black belt
66 and champion (Stevenson, 2009). As a person in a company obtains certain training, he acquires a belt. Usually,
67 a black belt is the leader of a project team and several green belts work together for the project team.

68 Motorola, GE, Allied Signal, IBM, DEC, Texas Instruments, Sony, Kodak, Nokia, Philips Electronics, LG,
69 Samsung, Hyundai groups etc. implements six sigma philosophy (Pyzdek, 2004). But Bangladeshi industries
70 are lack behind because of not yet implementing six sigma programs. So it is necessary to implement six sigma
71 programs immediately to cope with others world-class industries. Lastly, six sigma provides flexibility in the new
72 millennium of 3Cs, which are:

73 ? Changes: Changing society ? Customer: Power is shifted to customer and customer demand is high

74 ? Competition: Competition in quality and productivity.

75 The pace of change during the last decades has been unprecedented, and the speed of change in this new
76 millennium is perhaps faster than ever before. Most notably, the power has shifted from producer to customer.
77 The producer-oriented industrial society is over, and the customer-oriented information society has arrived. The
78 customer has all the rights to order, select, and buy goods and services. Specially, in e-business, the customer has
79 almighty power. Competition in quality and productivity has been ever increasing. Second-rate quality goods
80 cannot survive anymore in the market. Six sigma with its 4S (systematic, scientific, statistical and smarter)
81 approaches provides flexibility in managing a business unit. Six sigma improvement projects typically has one
82 or more objectives such as reducing defects, reducing cost, reducing product and/or process variability, reducing
83 delivery time, increasing productivity, or improving customer satisfaction.

84 4 III.

85 5 Research Methodology

86 Bangladesh Cable Shilpa Limited (BCSL), a leading telecommunication cable manufacturer, has been considered
87 as a case for implementing six sigma. Among other competitive companies, BCSL has been taken into account
88 since the company already has their own standard quality procedure but has the potentiality for further
89 improvements. With direct collaboration from the Production Planning & Quality Control Department, we
90 have identified the steps of implementation procedures. Initially eight quality parameters have been identified in
91 the targeted factory. The quality department has been working with two types of quality characteristics which
92 are physical and electrical. We have studied all the properties before and after extrusion process to get defect rate
93 of experimented eight specifications of the wire. In terms of length, the defect lengths have been cumulated to
94 calculate the defect per million opportunities (DPMO). This research has advanced through analyzing the sigma
95 level where DPMO has been utilized along with total defects and production. a) Quality Parameters Quality
96 has been checked and inspected with respect to 8 criteria in 8 steps - Five basic electrical characteristics shown
97 in Table 2 are maintained strictly by BCSL to meet technical as well as quality requirements. These are Loop
98 resistance, Insulation resistance, Mutual capacitance, Capacitance imbalance, and High voltage for in process
99 products like Quad and 10 pairs sub unit as well as for semi finished and finished products. When any one of
100 these specification limits is not met, the nonconforming portion is treated as defective. The major causes of
101 nonconformities are identified through root cause analysis and corrective actions are taken to rectify the process.

102 Defective portions are cut off. The nonconforming portions are to be reduced otherwise the process will not be
103 within the six sigma limit and the company will have to count a significant loss.

104 **6 d) Wire Specifications (After Extrusion)**

105 Cores are filled with compound (petroleum jelly) and wrapped into non hygroscopic tapes and laminated sheath
106 with aluminum tape and are insulated by black polyethylene. Conductor diameter have been calculated as 0.4,
107 0.5, 0.6, 0.9 mm as well as insulated wire diameter have been measured by digital micrometer. Tolerances of
108 conductor are 0.004 mm and 0.03mm respectively. Elongation of conductor have been measured and stated in
109 Table 3 IV.

110 **7 Results and Discussions**

111 Defects Per Million Opportunities (DPMO) is a measure of process performance. DPMO is the actual, observed
112 number of defects, extrapolated to every 1,000,000 opportunities. Opportunities are actually the quality
113 parameters against which the defects are identified i.e., they are the categories of defect types. DPMO is not
114 the same as defective Parts Per Million (PPM) since it is possible that each unit (part) being appraised may be
115 found to have multiple defects of the same type or may have multiple types of defects. A part is defective if it
116 has one or more defects. The number of defectives can never exceed the number of defects. IF each part only has
117 one characteristic that can be a defect, then DPMO and PPM will be the same. DPMO will always exceed or
118 equal to PPM for a given yield or sigma level of performance ("Defects Per Million", 2012, "How is the defects",
119 2012, and "Process Sigma", 2012). DPMO can be expressed as: A standard normal distribution table is taken
120 look up the DPMO value to determine the equivalent standard deviation which produces that level of DPMO.
121 Converting the quality metric DPMO to an equivalent first-time yield discloses the approximation $P = (DPMO /$
122 $10^6) = 1 - (16012.5 / 10^6) = 0.9839$. Statistically converting this first-time yield provides the quantity $Z = 2.14$
123 in rounded form. Most of the processes tend to exhibit instability of 1.5 Sigma over time. Although statistical
124 calculation indicates that 16012.5 defects/million are achieved when 2.14 process standard deviations (Sigma) are
125 between the mean and the closest specification limit, the target is raised to 3.64 Sigma to accommodate adverse
126 process shifts over time considering 1.5 Sigma process shift. Hence the Sigma level of the industry is 3.64.

127 V.

128 **8 Conclusion**

129 Sigma level is a sign of quality level of the industry. Sigma level of BCSL is 3.64. In Six Sigma the goal is to
130 achieve DPMO below 3.4. But the DPMO of BCSL is 16012.5. So this company's current process capability is
131 not good enough to produce zero defects. Most of the companies of Bangladesh are not achieving their expected
132 sigma level for lack of proper management, electricity, and skilled labor. Now a day's electricity problem is a
133 vital issue in this country. The company was counting a huge amount of per hour cable loss due to the electricity
134 problem.

135 Bangladesh is lack behind in quality sector as well as applying the quality tools like six sigma, TQM, KAIZEN,
136 5s etc. This paper has identified the current sigma level and quality position of the company. It can be
137 recommended that the quality tools have to be properly implemented to make the processes more capable.
138 DMAIC (an acronym for the procedural steps of Six Sigma: Define, Measure, Analyze, Improve, and Control)
139 which is a key principle of Six Sigma can be applied to enhance the quality level of the company. ¹



Figure 1:

2

- ? Diameter (before insulation)
- ? Elongation
- ? Conductor loop resistance
- ? Insulation resistance
- ? Mutual capacitance
- ? Capacitance imbalance
- ? Dielectric strength
- ? Other (time loss, water tightness, etc)

b) Physical Characteristics

Bangladesh Cable Shilpa Ltd. usually produces four types of telecommunication wire according to the customer requirements. The physical characteristics of the wires are listed in Table 1. Those characteristics including nominal, minimum, and maximum conductor diameters and percentage of elongation are maintained to meet technical requirements. The specifications corresponding to these quality characteristics are different for each individual wire type.

Figure 2: Table 2 :

3

e) Defect Magnitude specified conformities supplied by the customer in
 From BCSL production target quantities physical properties (diameter, elongation) and electrical
 of wire properties (loop and insulation resistance, Mutual
 and defective length for eight quality parameters of five
 consecutive days have been tabulated in capacitance, Dielectric
 Table 4. The strength) and others.
 magnitudes have been recorded for the
 deviation in

Figure 3: Table 3 :

1

Wire Type	Nominal conductor	Minimum conductor	Maximum conductor	Elongation
	Diameter (mm)	Diameter (mm)	Diameter (mm)	%
01	0.4	0.4	0.408	25-31
02	0.5	0.5	0.508	25-31
03	0.6	0.6	0.608	25-31
04	0.9	0.9	0.909	30-40

c) Electrical Characteristics

Figure 4: Table 1 :

8 CONCLUSION

Wire	Conductor	Conductor Loop	Insulation	Mutual	Capacitance	Dielectric
Type	Diameter (mm)	Resistance (?/km)	(max) Resistance (min) (M?.km)	Capacitance (max) (nF/km)	Imbalance (max) (pF/km)	Strength Between Conductors &
01	0.4	295.0	5000	55	500	0.5 KV AC
02	0.5	187.0	5000	55	500	0.5 KV AC
03	0.6	130.0	5000	55	500	0.5 KV AC
04	0.9	56.6	5000	55	500	0.5 KV AC
SL.	Wire type	Insulation	Conduction	Insulated wire	Wall Thick-	Conduction
No.		Material	Diameter (mm)	Diameter (mm)	ness (mm)	Elongation %
1	0.40/0.72	Foam-skin	0.396-0.402	0.71-0.18	0.14-0.18	18-25
2	0.40/0.82	Solid PE	0.396-0.402	0.81-0.83	0.19-0.23	18-25
3	0.50/0.90	Foam-skin	0.494-0.502	0.89-0.93	0.19-0.23	20-28
4	0.50/1.02	Solid PE	0.494-0.502	1.00-1.13	0.24-0.28	20-28
5	0.60/1.10	Foam-skin	0.594-0.602	1.09-1.13	0.24-0.28	20-28
6	0.60/1.22	Solid PE	0.594-0.602	1.20-1.24	0.29-0.33	22-31
7	0.80/1.63	Solid PE	0.794-0.802	1.61-1.66	0.39-0.43	22-31
8	0.90/1.75	Solid PE	0.896-0.903	1.72-1.76	0.41-0.46	22-31
9	0.90/1.65	Foam-skin	0.894-0.903	1.63-1.66	0.33-0.38	22-31
10	0.90/1.60	Foam-skin	0.894-0.903	1.58-1.62	0.31-0.36	22-31

Figure 5:

4

Date/	Target	Diameter	Elongation	Loop	Insulation	Mutual	Capacitance	Dielectric	Other	Total
November	(km)	(mm)	(mm)	resistance	resistance	capacitance	imbalance	strength		
2011				(?/km)	(M?.km)	(nF/km)	(pF/km)	(KV AC)		
13	4000	95	45	30	21	15	26	8	290	530
14	4000	83	59	68	27	26	6	4	310	583
15	4000	100	54	53	18	25	11	8	210	479
16	4000	78	86	28	26	35	16	14	240	523
17	4000	85	29	27	24	29	13	10	230	447
Total	20000	441	273	206	116	130	72	44	1280	2562

Figure 6: Table 4 :

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