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Critical Success Factors Assessment for Six Sigma Implementation in Manufacturing Indian Small and Medium Enterprises

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***Abstract*—The purpose of this study is to present the results from the survey conducted in manufacturing Indian small medium enterprises (SMEs), for the most part to center of attention critical success factors (CSFs) of Six Sigma implementation in Indian manufacturing SMEs and enlist significant benefits achieved from Six Sigma implementation in SMEs of manufacturing sector in India. The work is based on survey questionnaire appropriate for manufacturing Indian SMEs. The data analysis of the present study is based on descriptive statistics and also perform t test for getting results. The results are estimated by the descriptive analysis and reveal the impact of different CSFs of Six Sigma implementation in manufacturing Indian SMEs.**

Index terms - Critical success factors (CSFs), Six Sigma, Indian manufacturing SMEs and Six Sigma Benefits.

I. INTRODUCTION

All the enterprises wish for improving their manufacturing processes and management skills in order to endure long time in the market. The Indian SMEs are trying many improvement tools and techniques such as Six Sigma. The improvements in the product or processes can be achieved by eliminating defects, reduction in process variability, reduced operational costs and increasing customer satisfaction etc. [1]. Earlier, many improvement tools and techniques used by enterprises to satisfy their necessities but now a day, Six Sigma has become a most popular methodology having statistical base for focusing on eliminating causes of defects in the business processes or products.

Six Sigma was originated in the early 1980s to reduce failure rate at maximum level in five years at Motorola. Hence, Six Sigma implemented successfully in Motorola for achieving reduction in product failure rate, due to this motive, some other enterprises generated curiosity in Six Sigma [2] and it has an extension of quality initiatives [3]. Definition of Six Sigma by many academicians and researchers proposed all over the world [4, 5, 6] in different ways, Six Sigma aim is to eliminate waste and inefficiency, so that high level of customer satisfaction is expecting. Sigma is a Greek letter which stands for standard deviation that measures how extreme a given process deviates from precision. The fundamental approach in the wake of Six Sigma is that if you can find out how many "defects" in a product or process, you can puzzle out systematically how to moderate them and obtain as close to "zero defects" as achievable and purposely it means a perfection of 99.9997% or failure rate of 3.4 defects per million opportunities. Six Sigma level of quality is like parking a small vehicle in a huge area relatively [7].

Six Sigma approach was initiated from the electronic enterprises to other sectors and growing endlessly in dissimilar branches. It have also been implemented and singing very significant role in process, service enterprises [8-9], health care enterprises [10-11], automobile sector [12-13] as well as food distribution enterprises [14]. Six Sigma has also been encouraged towards small medium enterprises (SME) to remain competitive in the market but they may have lots of uncertainties on the subject of Six Sigma implementation.

This research paper is an attempt to analyze critical success factors (CSFs) of Six Sigma implementation in manufacturing Indian SMEs and make out noteworthy benefits achieved from Six Sigma implementation in SMEs of manufacturing sector in India.

II. RELATED WORK

A. Six Sigma move toward for small medium enterprises

Earlier, discussed with reference to origin of Six Sigma but in depth stepwise discussion on Six Sigma from origin to SMEs was essential for research view point. Six Sigma approach originated at Motorola in 1985 when enterprises decided to create imperfection free manufacturing processes. Positive results came after implementation of Six Sigma in Motorola then GE adopted it in mid 1990s. Six Sigma approach has become one of the most well-liked techniques implemented in different sectors all over the world such as companies named Sony, Texas instruments, Toshiba, Boeing, Allied signal, Kodak, Honeywell and many more implemented Six Sigma and generated massive amount of savings through Six Sigma [6]. Six Sigma approach also focused on business quality to generate product on zero defect rate by least cost of production at greatest profit. Some additional benefits have seen from Six Sigma incorporate improved design and increased customer satisfaction. Six Sigma approach became a synonym for improving quality, improving processes,

reducing process variability, reducing defects, reducing cost and improving customer satisfaction.

Six Sigma is based on different quality management theories (e.g.: Deming's 14 point for management, Juran's 10 steps on achieving quality) and in the beginning implemented in manufacturing processes and afterward product, purchasing, service, billing, marketing were also concerned.

Advancement of Six Sigma is long-lasting by adopting it as managerial approach to revolutionize culture of the organizations in several ways. It was a statistical approach or make use of statics in Six Sigma projects. All processes consists deviations, Six Sigma aims to lessen deviations by means of statics for project accomplishment. It was also being presented as a break through strategy because DMAIC process as break through or step by step goal achieving methodology [15]. Six Sigma key methodologies implemented to get better effectiveness of service enterprises and products delivery. It is a management tool or problem solving methodology that increases customer satisfaction by reducing waste in all the products, processes and services. Struggle for revenue has become increasing in every day and SMEs are trying to remain competitive in the market by producing more cost efficient products with the implementation of Six Sigma in it because Six Sigma approach can aid to improve effectiveness of small medium enterprises to a larger extent.

All enterprises call for cultural change in an organization for remains competitive in the market but employees of an organization may not be satisfied to change. These problems and issues arise within an organization should be handled by a good manager for successful implementation of initiative.

SMEs sector in India

According to the act approved by the Government of India in October 2006, Micro, Small and Medium Enterprises (MSMEs) are classified as under [16-17].

Table 1 Classification of Enterprises into Different Categories (effective from 02 October 2006)

Enterprises	Investment in Plant and Machinery	
	Manufacturing	Service
Micro	Up to Rs 25 lakhs	Up to Rs 10 lakhs
Small	Between 25 lakhs to Rs 5 crores	Between 10 lakhs to Rs 2 crores
Medium	Between Rs 5 crores to 10 crores	Between Rs 2 crores to 5 crores

B. Critical success factors in SMEs for implementing Six Sigma

Critical success factors (CSFs) are those factors that are significant to the success of any enterprises, it means that if objectives depended on the factors are targeted; the enterprises must fail [24], many other definitions of CSFs by researchers in literature [25, 26 and 27].

Critical success factors for implementation of Six Sigma identified from literatures and suitable CSFs considered in the present study [28, 29 and 30].

The management commitment, involvement and participation, Linkage between Six Sigma and customer and Linkage between Six Sigma and business strategy of an organization were found better critical success factors for successful Six Sigma implementation within UK manufacturing SMEs than others [20].

From the literature, it revealed that identified factors help in implementation of Six Sigma in SMEs and for survey of these factors were done by questionnaire constructed [19, 20 , 21, 31 and 32], distributed it to indentified small medium enterprises for evaluation of gaps in critical success factors. Data collected by either online survey or structured and semi structured interview conducted or both methods. After analysis of data collected, researchers has been differentiate CSFs involvement in SMEs [20] and identified most severe CSFs for implementation of Six Sigma in small medium enterprises. Some of critical success factors presented in literatures are shown in table 2 [32].

Table 2 Critical success factors for implementation Six Sigma

Authors	Critical Success factors
Hahn et al. (1999), Goh (2002), Coronado and Antony (2002), Kwak and Anbari (2006)	Top management commitment
Hendersen and Evans (2000)	Organizational infrastructure, link to human resources based actions (e.g. promotions, bonuses, etc.) and top management support.
Coronado and Antony (2002), Antony and Banuelas (2002)	Understanding of Six Sigma methodology, management commitment and involvement, understanding of tools and techniques, linking Six Sigma to customers, linking Six Sigma to business strategy, linking Six Sigma to suppliers, organizational infrastructure, project selection, project management skills, cultural change, training
Starbid (2002)	Identify core processes, customer needs and measures
Hayes (2002)	Management involvement, executive engagement, resources and communications
Johnson and Swisher (2003)	Sustained and visible management commitment, clear expectations, continuing

	education and training of participants and managers, project leadership
Anbari and Kwak (2004)	Management commitment, project planning and selection, organizational involvement, project management and control, continuous training, implementation methodology and cultural change
Kundi (2005)	Cultural change, top management support, employee training and education of Six sigma, effective communication of Six Sigma program, organizational infrastructure, use of Six Sigma methodology and role of innovative techniques.
Burton and Sams (2005)	Leadership commitment and support, make proper investment in resources, focus on customers and results, linking to business plan, communication and cultural change
Martins et al. (2006)	Continuous support of Six Sigma champion, cross functional teamwork, project management skill of project leader and knowledge of process of teamwork
Chakrabarty and Tan (2007)	Top management commitment, cultural change, education and training, clear performance metrics and customer focus
Kumar et al. (2008)	Top management involvement and linking to strategy
Rupa Mahanti and Jiju Antony(2009)	Management commitment and involvement, Training and education
Jiju Antony et al. (2009), Maneesh Kumar et al. (2009)	Organizational infrastructure, cultural change
Darshak A. Desai et al. (2012)	Management commitment and involvement, Training, Organizational infrastructure, cultural change

C. Methodologies used for implementing Six Sigma

Researchers all over the world suggest two key methodologies for implementation of Six Sigma: DMAIC (Define, Measure, Analyze, Improve and Control) [33, 34, 35 and 36] and DFSS (Design for Six Sigma) [37], the main purpose of both methods are different. Initially both methods were used for Six Sigma implementation and later on some modifications were exist such as DMADV (Define, Measure, Analyze, Design and Verify) and DCOV (Design, Characterize, Optimize and Verify) [38]. DMAIC process and goals are shown in figure 2.

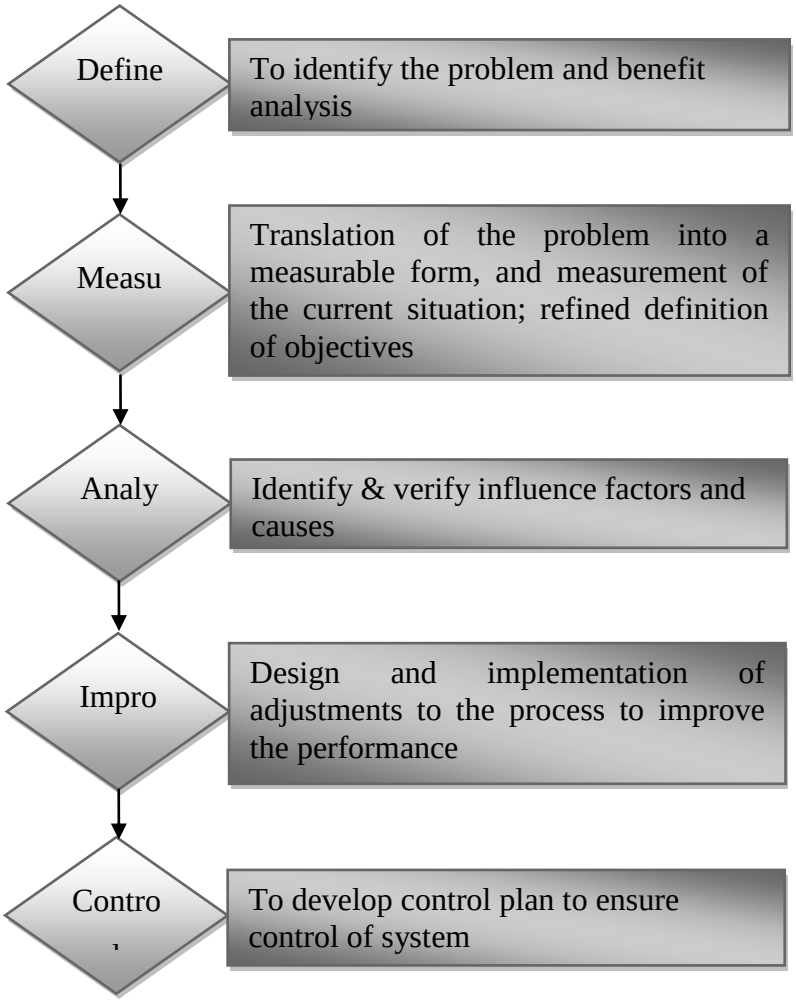


Figure 1 DMAIC process and goal

D. Benefits of Six Sigma in SMEs

There were many key benefits of Six Sigma in small medium enterprises such as reduce process variability, reduction in cost of operation, increase in profitability, minimize cost of poor quality, improved productivity, minimize cycle time, reduce customer complaints and sales improvement etc. [19-20] and literature also indicated weaknesses and strengths of SMEs by survey. Mostly Six Sigma programs have implemented to differentiate the organization from others by calculating net benefits from Six Sigma projects [39].

In SMEs, Six Sigma implemented very carefully to ensure that the knowledge and benefits generated from project of Six Sigma are sustained for long time [40]. Most of the benefits related to prevention and reduction of the defects which affected both processes and products quality [41]. It was found

that the profit was increased by controlling rate of rejection of chain bush in its organization [42]. Benefits of implementation of Six Sigma have been reported by large and smaller units. Literature also has evident that small medium enterprises have given less importance to quality culture [12].

III. RESEARCH OBJECTIVES, METHODOLOGY & DESIGN

A. Research objectives & methodology

The fundamental objective of this research is to "analyze the critical success factors of Six Sigma within manufacturing Indian SMEs to which Six Sigma is being implemented" and this can be achieved by constructing many research questions systematically, the objective is further classified into various number of specific research questions as follows:

- To study of the status of Six Sigma implementation in manufacturing Indian SMEs.
- To study the critical success factors (CSFs) for implementation of Six Sigma in manufacturing Indian SMEs.
- To suggest most CSFs for better implementation of Six Sigma in manufacturing Indian SMEs.

To achieve above objectives, a survey questionnaire was prepared with the help of literature. It was framed to provide a bottom line for Six Sigma practices by manufacturing SMEs in India. It consists of four parts:
(1) SMEs demographic information for survey.
(2) SMEs experience with implementation of Six Sigma.
(3) CSFs for implementation of Six Sigma in manufacturing Indian SMEs.
(4) Benefits achieved by manufacturing Indian SMEs.

Online questionnaire survey of Indian manufacturing small and medium enterprises was conducted to understand the status of Six Sigma implementation. Also this study can help to explore the critical success factors of Six Sigma implementation and identify the benefits achieved from Six Sigma implementation.

The questionnaire was sent to 1500 manufacturing Indian SMEs. The manufacturing Indian SMEs were randomly selected covering different sectors and size. Out of 1500 questionnaires mailed, 301 useful responses were received, duly completed, revealing a 20.06 per cent response rate.

The questionnaire focused on critical success factors and benefits achieved from Six Sigma implementation as well as it included demographic information of organization. CSFs and benefits are measured by seven point likert type scale (CSFs: 1 = Not at all important, 7 = Crucial; Benefits 1 = Very negative benefits, 7 = Crucial). The all contents of questionnaire were reviewed by the knowledgeable persons of Six Sigma implementation. This process helped to identify the suitable questions for organization.

B. Research Design

Figure 2 shows that the present study progressed by setting research objectives that led to an in-depth review of the literature. The literature review helped to identify the gaps and, hence, the ensuing research questions. This is followed by the designing of an appropriate research method to address the research question, which can guide the data collection method. After the data collection, the data can be analyzed and research findings will be drawn. These research findings are to be validated against the research objectives, and conclusions, along with recommendations for further research.

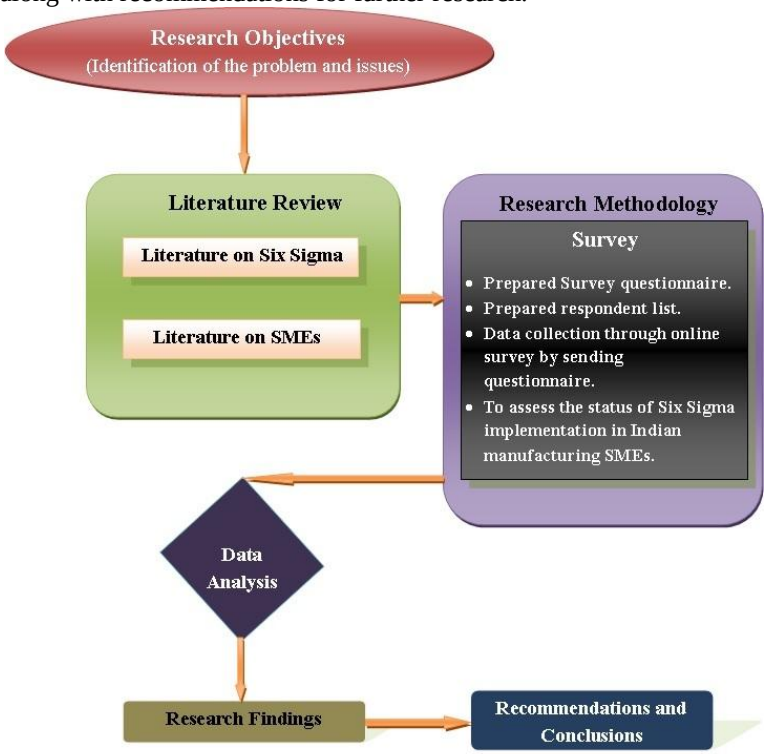


Figure 2 Research Design

IV. RESULTS AND SURVEY ANALYSIS

A. Demographic Information of SMEs

Data were collected from 301 organizations. Out of 301 organizations, 136 organizations were found to be small, while 165 organizations fulfilled the criteria of medium enterprises. As table 1 shows that the type of small and medium sized organizations considered for this study.

Table 3 Size distribution of manufacturing Indian SMEs where Six Sigma is operational

Types of organization				
	Frequency	Percent	Valid Percent	Cumulative Percent
Small	136	45.2	45.2	45.2
Medium	165	54.8	54.8	100.0
Total	301	100.0	100.0	

The research findings revealed that the greater part of the manufacturing Indian SMEs had a financial turnover of Rs 1 – 5 crores (see table 4). Further, around 90% of the manufacturing Indian SMEs have the annual financial turnover up to Rs 10 crores. These results center of attention towards the need to implement Six Sigma methodology that could result in growing profit margins and enhancing the performance of manufacturing Indian SMEs [22].

Table 4 Annual financial auto component Indian SMEs turnover (Rs)

Annual Financial Organizations turnover (Rs)				
	Frequency	Percent	Valid Percent	Cumulative Percent
10 Lacs – 1 Crore	60	19.9	19.9	19.9
1- 5 Crores	166	55.1	55.1	75.1
5-10 Crores	45	15.0	15.0	90.0
Over 10 Crores	30	10.0	10.0	100.0
Total	301	100.0	100.0	

Table 5 Profile of the respondents

Current Position of the Respondents				
	Frequency	Percent	Valid Percent	Cumulative Percent
CEO/ Director/ General Manager	166	55.1	55.1	55.1
Quality manager	15	5.0	5.0	60.1
Departmental Head	45	15.0	15.0	75.1
Others	75	24.9	24.9	100.0
Total	301	100.0	100.0	

Further, the research findings showed that management was extensively shown their involvement in quality matters, as more than 50% of the respondents were a general manager/director/CEO. Quality is more important for SMEs than others, table 5 showed that the current position of the respondents.

Customer center of attention is the top quality product with zero defects. Hence, respondents were asked to draw attention to give you an idea about avenues used by them to concentrate on customer and to capture their response. A list of opinions was given them from which to choose and responses recorded in table 6. The results reveal that all 301 manufacturing Indian SMEs measured customer satisfaction. The majority (55.1 percent) of manufacturing Indian SMEs used "customer complaints", followed by "surveys" (39.9 percent) and "delivery times" (5 percent) to measure customer satisfactions (see table 6). These results are similar to the findings in the Australia and UK SMEs. It showed that most of the companies trusted on customer complaints to receive the feedback of product. Customer complaint is immediate approach to measure customer satisfaction and usually it is customer initiated approach.

Table 6 How does your enterprise measure the customer satisfaction?

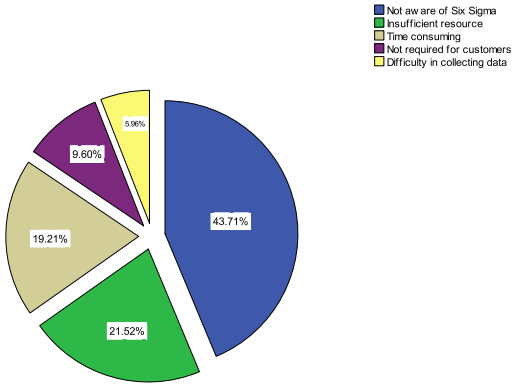
How does Company Measure Customer Satisfaction?				
	Frequency	Percent	Valid Percent	Cumulative Percent
Surveys	120	39.9	39.9	39.9
Delivery times	15	5.0	5.0	44.9
Customer Complaints	166	55.1	55.1	100.0
Total	301	100.0	100.0	

Table 7 Important criteria that helped to win customer loyalty

Important Criteria That Helped to Win Customer Loyalty				
	Frequency	Percent	Valid Percent	Cumulative Percent
Manufacturing Quality	135	44.9	44.9	44.9
Price economic	61	20.3	20.3	65.1
Wide Product range	30	10.0	10.0	75.1
Delivery lead- time	75	24.9	24.9	100.0
Total	301	100.0	100.0	

Further, to assess the purpose of manufacturing Indian SMEs targeting on their customers, the manufacturing Indian SMEs were asked to highlight the most important criteria that helped to win customer loyalty from a list. They ranked manufacturing quality highly, followed by delivery lead time, price economic and wide product range (see table 7).

Figure 3 Reasons for not implementing Six Sigma in Indian Manufacturing SMEs



B. Critical success factors analysis

A t-test was performed to identify statistically the mean value for importance of critical success factors is significant. Result analysis of CSFs show that each factor is statistically significant in terms of importance and application of CSFs within manufacturing Indian SMEs.

To meet the objective of CSFs of Six Sigma implementation in manufacturing Indian SMEs as entire the respondents were asked to rank the CSFs in a scale of 1 to 7 as mentioned above. Accordingly respondents have provided their rating of all CSFs and then calculated individual mean score of all CSFs. Table 8 indicates the mean score of 29 CSFs as rated by manufacturing Indian SMEs.

As evident from the table 8 "management commitment, involvement and participation", "customer satisfaction", "organizational infrastructure", "project planning and management" and "linking Six Sigma to business strategy" are the most important factors considered by manufacturing Indian industries for successful implementation of Six Sigma. These factors are with mean score of above 6.0 which is high and it revealed that they are crucial for implementation of Six Sigma. The CSFs such as "Process documentation", "regular audits", "strategic vision" and "incentive program" were not ranked very high.

Table 8 Importance of critical success factors of Six Sigma implementation in manufacturing Indian SMEs

Critical Success Factors	Importance (Mean)	Sig. [a] Value
Leadership	5.60	.000
Management commitment, involvement and participation	6.46	.000
Integrating Six Sigma with the financial infrastructure	5.40	.000
Organizational infrastructure	6.26	.000
Cultural change	5.75	.000
Education and training	5.57	.000
Fact based decision making	5.40	.000
Linking Six Sigma to customers	5.50	.000
Linking Six Sigma to business strategy	6.05	.000
Linking Six Sigma to employees	5.50	.000
Linking Six Sigma to suppliers	5.36	.000
Communication	5.25	.000
Project management skills	5.55	.000
Project planning and management	6.20	.000
Project prioritization and selection	5.62	.000
Uses of innovative techniques	5.09	.000
Understanding of six sigma methodology	5.65	.000
Understanding of six sigma tools and techniques	5.70	.000
Employees commitment	4.90	.000
Customers involvement	5.00	.000
Customers satisfaction	6.32	.000
Suppliers involvement	4.90	.000
Knowledge Sharing	5.10	.000
Process documentation	4.32	.000
Regular audits	4.19	.000
Strategic vision	4.13	.000
Incentive program	3.87	.000
Specialized team for Six Sigma	5.10	.000
Make proper investment in resources	5.21	.000

Note: [a] Test performed at 5 per cent significance level

C. Benefits analysis

To assess the outcome of implementing Six Sigma program, the respondents were agreed a list of various benefits or performance measure/indicators of Six Sigma implementation in manufacturing Indian SMEs as whole the respondents were asked to rate the benefits in a scale of 1 to 7 as mentioned above. Therefore, respondents have provided their rating of all benefits and then calculated individual mean score of all performance indicators. Table 9 indicates the mean score of 27 benefits as rated by manufacturing Indian SMEs.

The descriptive analysis suggested that the SMEs were not achieving the full benefits after taking Six Sigma implementation in manufacturing Indian SMEs. The maximum mean score attained was 6.41 for the benefits 'increase in customer satisfaction' followed by 'reduction in customer complaints', 'reduction of defects', 'reduction in operational costs' and 'reduction of production costs' etc. The details of the mean values are mentioned in table 9.

Table 9 Benefits achieved from implementation of Six Sigma in manufacturing Indian SMEs

Benefits	Mean Score
Reduction of scrap rate	5.45
Reduction of cycle time	5.20
Reduction of delivery time	5.29
Reduction of defects	6.40
Reduction in process variability	5.65
Reduced work in progress	5.39
Reduced inspection	5.39
Reduced project time	5.34
Increase in productivity	5.95
Reduction of production costs	6.20
Reduction in operational costs	6.22
Reduction in cost of poor quality	5.70
Reduction in customer complaints	6.40
Increase in profitability	5.80
Improved sales	5.60
Improved capacity and output	4.95
Reduction in raw material and finished goods inventory	5.27

Increase in customer satisfaction	6.41
Increase in employee satisfaction and level of commitment	5.45
Increased employee efficiency	5.55
Reduction in technical support enquiries	5.55
Reduction in rework on purchase order	5.68
Reduction in floor space utilization	4.61
Improved technical support process	5.20
Improvement in company image	5.73
Improved attitude of employees towards quality and problem solving	5.68
Improved attitude of top management towards quality and problem solving	5.75

Note: [a] Test performed at 5 per cent significance level

V. CONCLUSION

For overall competitiveness, manufacturing Indian SMEs are striving to achieve overall enterprise performance in their business. Importance of Six Sigma is growing in manufacturing Indian SMEs to satisfy the organizations need. The study was aimed to find out the most CSFs and benefits achieved by Six Sigma implementation in manufacturing Indian SMEs. As revealed from the study manufacturing Indian SMEs have similar influence on the top CSFs of Six Sigma implementation as in UK SMEs. However, analysis revealed that each factor is statistically significant in terms of importance and application of CSFs within manufacturing Indian SMEs but 05 CSFs out of 29 were found most critical as mean score of 6 and above.

The maximum mean score attained was 6.41 for the benefits increase in customer satisfaction and it was 6.40 for both reduction in customer complaints and reduction of defects and also reduction in operational and production cost was attained higher value of mean score, these crucial benefits achieved by implementation of Six Sigma in manufacturing Indian SMEs.

Manufacturing Indian SMEs have already implemented Six Sigma methodology as a breakthrough continuous improvement strategy for enhancing performance of SMEs. A broad study regarding CSFs and barriers of Six Sigma implementation in auto components Indian SMEs was required since Six Sigma is getting more importance among manufacturing Indian SMEs. This study can help other manufacturing Indian SMEs, who have yet not implemented Six Sigma.

Since the study was based on survey analysis, the limitation of the study was to conduct semi structured interviews of black belts for collecting data. Further research can be taken up to analyze critical success factors based on other sectors.

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