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Scope of six sigma study in automobile industries to control pollution due to heavy metals and other pollutants

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Abstract

Six sigma is a set of tools and strategies for process improvement. Our six sigma study revealed that the automobile manufacturing unit's major focus was on customer satisfaction and quality of the product. As per six sigma concept, the emphasis was given first on environmental management which is a mandatory requirement. After our study, an ETP was installed by the unit to remove heavy metals, dyes and other chemical impurities from their waste water, so that the treated effluent meets the norms prescribed by the pollution control board. The study indicated that automobile industries may use six sigma tools to make their system environment friendly and comply with legal regulation to protect our environment.

Key words: Six sigma, Pollution, Human health, Effluent, ETP

Introduction

The demand of automobile sector is increasing with the increase in world population for improved design and model of automobiles to meet the requirements of fashion and comfort. The automobile parts are being manufactured by several industries to meet the growing demands. Due to heavy demands of the automobile, India has widely set up in-house manufacturing industries to reduce the time of delivery and cost. It has become a good source of income that contributes to Gross Domestic Product (GDP). However, this has brought both consequences to such countries either in a positive way which is an improvement of economy or in a negative way attributed to environmental pollution. The problem of environmental pollution is arising tremendously because of disposal of industrial waste[4-6]. Heavy metals, hazardous dyes and other organic as well as inorganic impurities are present at significant levels in automobile industrial waste water. If such waste waters are discharged into surface waters as such, without any treatment, they severely affect the environment and public health. Toxic metals and trace metals flow from automobile effluents to water and soil are very dangerous from health point of view[6,7].

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At present, the main focus of automobile industries is to increase the production without any concern towards environmental degradation and human health. The control of product waste generation, improves the product quality and reduces the defects by using six sigma tools and techniques (control of defects per millions unit). But, most of the automobile industries situated in Delhi, Uttar Pradesh, Haryana, Maharashtra, Gujarat etc. discharge their effluents, without any treatment, into public sewers which are ultimately disposed off into streams along with domestic sewage resulting in severe environmental degradation.

The reason for not installing effluent treatment plants (ETP) by these industries is lack of information on monitoring of hazardous processes such as electroplating, paint shop, metal finishing along with main process like casting, moulding, pressing, punching etc., Six sigma is a unique technique to capture the defects as well as hazards up to per million unit. It improves the product quality drastically and provides an innovative idea for environmental management in automobile industries.

The present project deals with utilization of six sigma tool in an automobile manufacturing unit in capturing the pollution hazards and its immediate abatement with proper protection at a low cost, so that the treated effluent meets the norms prescribed by the pollution control board.[1,2].

What is Six sigma?

Six Sigma is a set of tools and strategies for process improvement originally developed by Motorola in 1985. Six Sigma became well known after Jack Welch made it a central focus of his business strategy at General Electric in 1995 and today it is used in different sectors of industry.

Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes. It uses a set of quality management methods, including statistical methods, and creates a special infrastructure of people within the organization ("Champions", "Black Belts", "Green Belts", "Orange Belts", etc.) who are experts in these very complex methods. Each Six Sigma project carried out within an organization follows a defined sequence of steps and has quantified financial targets (cost reduction and/or profit increase).

The term *Six Sigma* originated from terminology associated with manufacturing, specifically terms associated with statistical modeling of manufacturing processes. The maturity of a manufacturing process can be described by a *sigma* rating indicating its yield or the percentage of defect-free products it creates. A six sigma process is one in which 99.99966% of the products manufactured are statistically expected to be free of defects (3.4 defects per million), although, this defect level corresponds to only a 4.5 sigma level. Motorola set a goal of "six sigma" for all of its manufacturing operations, and this goal became a byword for the management and engineering practices used to achieve it.

The Six Sigma program received attention after Motorola received the Malcolm Baldrige National Quality Award. Its most recent revival by former Motorola employees Dr. Mikel Harry and Richard Schroeder has

been widely noticed. Jack Welch's public endorsement of Six Sigma advanced the wide-spread adoption of the process. The American Society for Quality's unprecedented sponsorship of this program has also aided in its spread.

Six Sigma is a proven program for translating the continuous improvement into business results. The cost savings focus of Six Sigma makes the extension of the program to the supply base attractive. A supply strategy development process consistent with a Six Sigma environment will include an analysis of the supply base environment. The environment may be analysed on a number of levels of process/project. Each level has its own mini environment[8,9].

Six Sigma as a process has been around for years as a way to reduce errors and improve processes. It has only been recently, however, that the concept of green Six Sigma has started really catching on. Green Six Sigma helps companies not only to deal with the traditional issues within manufacturing and non-manufacturing process, but it also helps companies in reducing their environmental impact.

Six Sigma Study in Automobile Sector :

Six sigma studies in Automobile sector is an innovative idea. Our studies in automobile sector during the course of Six sigma (certificate awarded by ASSOCHAM & QCI) revealed that almost every automobile industry is widely using six sigma tools and techniques for control of their product's defects, but, without focusing on environmental hazards. They are adopting the environmental factors only to make their factory neat and clean by using 5S or 6 S, TPM programs and not looking outside factors where discharge of hazardous effluent to surface water is polluting our environment. This has become health hazards to human health and has become a critical issue for our next generations[10]. Wastewater treatment is essential to allow industrial effluents to be disposed without bringing danger to human health as well as to prevent unacceptable damage to the natural environment (Li *et al.*, 2004).

The effluent in automobile industries are mainly generated from electroplating, phosphating, anodizing, metal finishing/cleaning and paint shop which create all types of pollution such as air, land and water pollution. The main impurities in the effluence discharged by the automobile sectors are heavy metals, hazardous dyes, inorganic and organic chemicals, oil and greases etc.

Government's Rules and Regulations:

Automobile wastes are potentially hazardous to human health and the environment when they are improperly managed. These wastes mainly generated by the electroplating, metal finishing, paint shop and other processes. Such wastes create air and water pollution and are hazardous to the environment.

Keeping in view the hazardous nature of industrial effluents the government has made the following regulations-

- Environment Protection Act 1986
- Air (Prevention and Control of Pollution) Act 1981
- Water (Prevention and Control) Act 1974
- Hazardous Wastes (Management and Handling) Rules, 1989

- The North India Canal And Drainage Act 1873

Central Pollution control board, Ministry of Environment & Forest, Govt. of India issued notice to all their sub offices in Sep 2008 in the name of Parivesh (waste minimization & eco-friendly electroplating process), to control the issue of electroplating and state that it is very difficult to find out the distribution of production between organized/small scale/tiny/ unorganized sectors because these plants can be obtained in local market and most of the industries install these plants side by side along with their main production. Hence, there is no idea to issue a notice to them to install an ETP. They assumed that approximately 18000 ton chemicals are being used by organized sector and 10000 ton chemicals are being used by unorganized sector. Therefore approximately 36% industries are contributed by the unorganized sector.

The Chemicals used in various electro-plating operations are numerous. These chemicals can be classified generally as

(i) Acids and Alkalis for cleaning purpose
(ii) Inorganic Chemicals, particularly heavy metals, which take part in reactions pertaining to plating
(iii) Organic chemicals which help in achieving certain properties or to enhance the process of plating.

Often, some of these chemicals are unknown to both users and traders, as they are traded as proprietary items manufactured by Chemical companies.

Recently India's leading news paper 'The times of India' published a news that the Bombay High Court on 11 Jan 2012 has directed electroplating units in Mumbai to install effluent treatment plants (ETPs) and scrubbers while hearing a petition stating that such effluents are polluting the city's water and air. A division bench of Chief Justice Mohit Shah and Justice Roshan Dalvi was hearing a petition filed by Solomon Mordecai, a former employee of an electroplating unit, stating that liquid effluent discharged by such units can recklessly pollute the water and the solid waste when burnt, pollute the air.. Some 17 electroplating units filed an intervention application. Their advocate, R V Govilkar, said that his clients will install ETPs and scrubbers. The 100-500 litres of liquid effluents discharged per day will be carried in concealed containers to the effluent treatment plant at Taloja. MPCB's advocate Sanjay Patki told the court that it is not a practical solution. The judges have directed units to install ETPs and scrubbers by February 28, 2012.

Routes of Environmental Effects :

The environmental effects are caused by the pollutants through several routes as mentioned below-

- By directly reacting with air, water and soil, resulting in degeneration or disintegration,
- By accumulating as persistent chemicals (geo-accumulation)
- By entering environmental pathways and transcending from non-living to living beings, causing *toxicity* to living organisms and
- By entering into food chain–finally affecting humans and cattle.

Some of the pollutants are carcinogenic, while others are mutagenic. Central and most

important in this matter are health effects on workers, who are exposed routinely and persistently. Over a period of time such exposures, even at a low level, have been known to cause diseases and various infirmities. Moreover, the pollutants can enter the environment through air (particulates, gases and vapours), water (both in soluble and suspended form) and soil (as sludge, and leachate reaching ground-water).

The toxicity of these metals has also been documented throughout history: Greek and Roman physicians diagnosed symptoms of acute lead poisoning long before toxicology became a science. Today, much more is known about the health effects of heavy metals. Exposure to heavy metals has been linked with develop-mental retardation, various cancers, kidney damage, and even death in some instances of exposure to very high concentrations. Exposure to high levels of mercury, gold, and lead has also been associated with the development of autoimmunity, in which the immune system starts to attack its own cells, mistaking them for foreign invaders. Autoimmunity can lead to the development of diseases of the joints and kidneys, such as rheumatoid arthritis, or diseases of the circulatory or central nervous systems. Once emitted, metals can reside in the environment for hundreds of years or more. Evidence of human exploitation of heavy metals has been found in the ice cores in Greenland and sea water in the Antarctic.

The following substances/ heavy metals which are widely used by the electroplating, chemical washing and pain shops are adopted by the automobile industries:

1. Cyanides :

Cyanide is extremely toxic to humans. Acute (short-term) inhalation exposure to 100 milligrams per cubic meter (mg/m3) or more of hydrogen cyanide causes death to humans. Acute exposure to lower concentrations (6 to 49 mg/m3) of hydrogen cyanide causes a variety of effects in humans, such as weakness, headache, nausea, increased rate of respiration, and eye and skin irritation.

2. Chromium :

Chromium is one of the high priority persistent, bio-accumulative and toxic (PBT) chemicals that do not readily break down in the environment. It is not easily metabolized, may accumulate in human or ecological food chains through consumption or uptake and may be hazardous to human health or environment. A PBT chemical, once released to the environ-ment, may present increasing long term toxic effects to human health and the environment, even if the release was of a small amount. Chromium enters the environment mostly in the Chromium (III) and (VI) forms. It cycles between the soil, the atmosphere, surface and ground waters. Chromium (III) is considered safe, whereas Cr(VI) is highly toxic.

3. Cadmium :

Cadmium does not break down in the environment, but can change forms. Along environmental pathways and food chain in particular, fish, plants, and animals take up cadmium from the environment. In the electro-plating work place, Cadmium may enter the human body through breathing (if Cadmium dust is in the indoor air), eating contaminated

foods containing it; and most importantly, drinking contaminated water. The contamination of drinking water contributes to by far the greatest potential of environmental hazard, apart from Cadmium bearing sludge disposal.

4. Lead :

Aside from smoke, lead is probably the oldest human-made atmospheric and occupational toxin, dating back at least 8,000 years to the first lead-smelting furnaces. Today, lead poisoning remains the single most significant preventable disease associated with an environmental and occupational toxin.

5. Copper :

Considerable data indicate that copper does not bio-magnify in the food chain. The typical ratio of the concentration of copper in plants to that in soil is estimated at 0.25 (or 25%). Most plants contain less than 10 ppm copper on a dry-weight basis, and concentrations in animal foods are 2 to 4 ppm, with dairy products containing less than 1 ppm.

6. Zinc :

Harmful effects from too much zinc generally begin at levels from 10 to 15 times higher than the recommended dietary allowances of 5, 12, and 15 milligrams per day (mg/day) for infants, women and men, respectively.

7. Nickel :

About 10% of women and 2% of men in the population *are highly sensitive* to nickel. A portion of these sensitive people can develop skin rash called nickel dermatitis if they are exposed to nickel through direct contact. This is the most common type of reaction to nickel exposure. Exposure to readily water soluble nickel salts occurs mainly during the electrolytic refining of nickel (producing industries) and in electroplating (using industries).

8. Tetrachloroethylene (TCE) or Perchloroethylene :

Tetrachloroethylene is widely used for metal degreasing (Vapour cleaning) and dry cleaning operations. The main effects of tetrachloroethylene in humans are neurological, liver, and kidney effects following acute (short-term) and chronic (long-term) inhalation exposure. Adverse reproductive effects, such as spontaneous abortions, have been reported from occupational exposure to tetrachloroethylene;

9. Trichloroethylene :

Trichloroethylene used in degreasing operations is the chief source of atmospheric presence of this chemical. Acute (short-term) and chronic (long-term) inhalation exposure to trichloroethylene can affect the human central nervous system (CNS), with symptoms such as dizziness, headaches, confusion, euphoria, facial numbness, and weakness. Liver, kidney, immunological, endocrine, and developmental effects have also been reported in humans[3].

A Case Study :

Six Sigma study may be made beneficial to the environment by removing heavy metals, metal dyes and other pollutants from the effluent. In an organization, all the concerns are important because defects control and

customer satisfaction directly affects their business. Six sigma saves the manufacturing cost but on the other side installation of ETP is cost a consuming process and the management does not want to bear extra cost.

During our detailed study on six sigma in a unit engaged in manufacturing of automobile spare parts for world's leading car manufacturing company, we found that there were around 17 scopes for improvement. Most of the scopes were related to product quality, customer satisfaction, failure to meet deliveries to their customers and effluent discharge without proper treatment *etc*. All the scopes were discussed to meet organization's six sigma demand. One scope was related to organization's quality which is a legal issue and the remaining 16 scopes were related to product quality and customer satisfaction. The company agreed to comply with the legal requirements on priority basis, the issue which was creating environmental pollution (air, land & water)[11,12].

Initially the company was discharging electroplating, metal finishing and paint shop waste to the domestic sewage directly without proper treatment and dumping solid waste to domestic garbage. The reason for not to installing an effluent treatment plant was that the company had taken approval from the local authority for sheet metal casting, moulding, pressing and punching operations and started functioning as per the approved process. But, they were doing all processes like electroplating, metal finishing, painting, powder coating and galvanizing, in-house to avoid any delay in deliveries to customers. The company installed electroplating, metal finishing, painting, powder coating and galvanizing equipment and process machines without any knowledge about the nature of effluent. They were discharging the process effluents into the environment as such. They had not made any necessary arrangement to treat these effluents as per the norms prescribed pollution control boards.

Characteristics of Automobile Effluent:

The effluent being discharged by the unit was collected from the drain of the factory and sent to a laboratory for analysis to know the concentration level of various pollutants present in the effluent. The results are summarized in Table-1.

Table 1. Physicochemical Properties of the Effluent

S. No	Test Parameter	Test Result	S. No	Test Parameter	Test Result
1	pH	5.8	11	Chromium(total)	30.00 mg/l
2	Conductivity	2660 µs/cm	12	Aluminium	0.001 mg/l
3	Colour	Sea green	13	Copper	0.323 mg/l
4	TDS	384 mg/l	14	Manganese	2.045 mg/l
5	TSS	67 mg/l	15	Cadmium	0.513 mg/l
6	Sulphide	0.2 mg/l	16	Zinc	0.428 mg/l
7	Free Chlorine	1.0 mg/l	17	Lead	0.603 mg/l
8	BOD	135 mg/l	18	Nickel	95.00 mg/l
9	Calcium	135 mg/l	19	Iron	14.39 mg/l
10	Oil & grease	3.0 mg/l	20	Tin	0.693 mg/l

The above data indicated that the effluent had high conductivity due to metal ions present in high concentration; The concentration of heavy metals, particularly Chromium and Nickel was very high because of the processes involving these metal ions. These heavy metals are highly toxic from health point of view. The concentration of iron was also on higher side. After knowing the hazardous nature of the effluent being discharged to the domestic sewage, the organisation immediately installed an effluent treatment plant (ETP). As a result, all the parameters in the treated effluent were within the permissible limits prescribed by the pollution control board[13-16].

In the present Six Sigma Green belt project the main purpose of the study was to have a thorough understanding of the theoretical concepts and their practical application by being placed in the actual work environment

- To prevent environment pollution due to heavy metals and dyes discharged to the surface water without treatment.
- To prevent losses occurred from the absenteeism of employees.
- To improve productivity of staff works by utilization of manpower in an appropriate manner.
- To understand their relevance and find the extent to which they are actually being applied in the work situation;
- To have an in-depth knowledge of the function of the organization through actual work experience.
- To improve customer satisfaction level.

SWOT Analysis :

Correctly analyzing and responding to the supply environment is important to achieve the success of process management. A SWOT analysis (Strengths –Weaknesses – Opportunities – Threats) is a form of environmental analysis, allowing for the segregation of the environment into internal (strengths and weaknesses) and external (opportunities and threats) as well as positive and negative environments as shown below-.

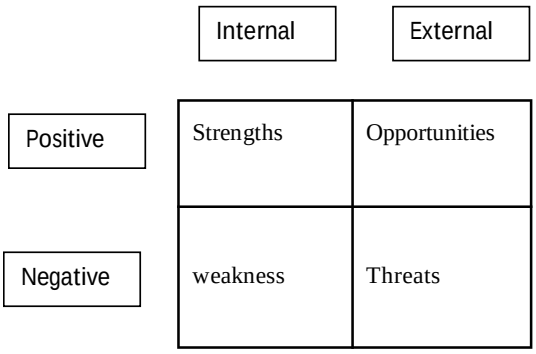


Figure-1. SWOT Analysis

The internal environmental assessment may include corporate culture, competitive priorities, functional relationships, and reward/ measurement systems. External environmental assessments address competitive, cultural, economic, legal, and political considerations.

This analysis reveals the impact of not complying the legal requirements, on the factory. If we take up this step in a positive manner then we may get new opportunities from the big clients who are followers the environment factors and if we take up this step in a negative way then we can get industry closure notice from state pollution control board any time or we may lose our business partner.

Cause-and-Effect Analysis :

A typical cause and effect analysis, a common tool within the Six Sigma toolbox, addresses six major cause categories, including the analysis of the environment (Figure 2). Often the environment is ignored in a cause-and-effect analysis even though it is known to be a major contributor to defective results or a major barrier to the desired effect. The omission is not due to oversight, but rather due to the fact that environments can be expensive, impractical, or in some cases, impossible to change. While it is possible to change internal environments, it is always desirable to understand the environment in order to change the parts of the environment we can influence and make our system robust to the aspects of the environment we cannot change. The cause-and-effect diagram provides an opportunity to verify that all major contributing causes are addressed, either directly or by modifying other major cause categories.

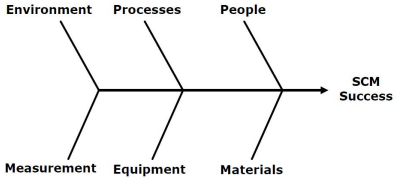
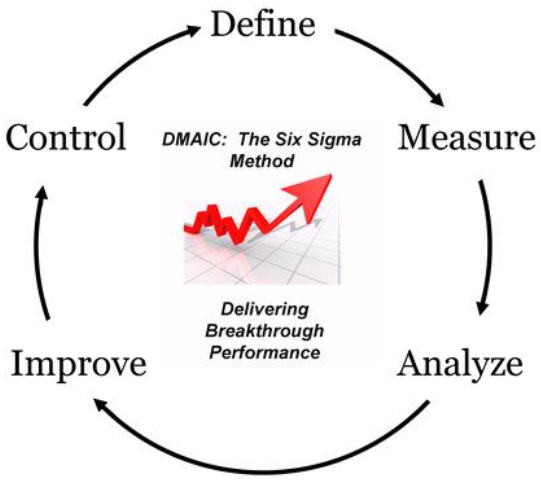


Figure 2. Cause-and-Effect Diagram

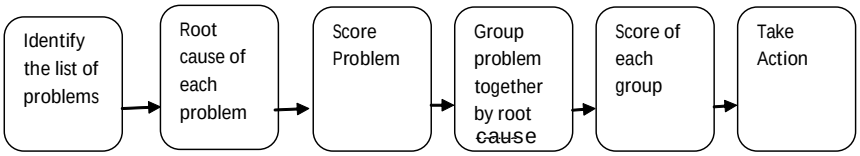
The following steps were involved in Six sigma green belt project.



1. Define Phase

A. Pareto Analysis

There were several types of complaints/ problems identified in the factory in the past and several factors were identified in majority, which affect the customer's satisfaction and stake holder's satisfaction.



During the study we identified all the areas, analyzed the root cause of each problem, made score of each problem and then made a group's code. We found that score of legal compliance is on peak and hence environment concern needs to be rectified, which is a critical concern and hazardous to surrounding species.

The problematic area and results of the six sigma (Green Belt) study is summarized below:

Table 2. Problematic area and results of the six sigma (Green Belt) study

S. No.	Problem (Step 1)	Cause (Step 2)	Score (Step 3)	Group problem (Step 4)	Group Score (Step 5)
1	ETP system not installed for treatment of effluent.	Not aware about the environmental concern	Legal regulation	D	**D= Legal regulations A=Factory absentism/other problem =93, B=Customer related problem =303 C=Resources =120 Total complaints /problems =516**
2	Product planning not done on time	Staff not sufficient & due to absentism	15	A	
3	Failure to meet quality as per customer requirements.	Quality team not dedicated & absentism	62	B	
4	Error in invoices send to customers	Software not available & manual calculation	18	A	
5	Sample approval not taken on time	Shortage of staff and absentism	12	A	
6	Failure to meet customer delivery time	Logistic staff absentism,manual entries,planning not done,transportation not book on time,	76	B	
7	Product not identified.	Lot number not issued.	05	A	
8	Labour salary not paid on time.	Cashier was absent	10	C	
9	100% goods/parts not ready at the time of quality inspector of customer.	Communication error/lack of coordination between QC & production team	130	B	
10	Material not transported with proper safety.	Packing method not known	11	A	
11	Suppliers are not providing raw materials on time.	Due to lack of coordination & reminder not sent	10	A	
12	Production records not kept by the factory/production team.	No value understand about the records	9	A	
12	Leakage of roof and problem cause during raining season.	Lack of building maintenance	03	A	

13	Labour toilet not available on top floor.	Lack of space on top floor	5	A	
14	Quality report not filled on customer data sheet	Absentism of logistic team	35	B	
15	New machinery not purchasing for expand of production.	No quotation received by team	30	C	
16	Stock inventory control not done and shortage of raw materials sometimes	Lack of staff of store/purchase dept.	05	A	
17	ERP system not installed to track delivery/ reminder set	No staff motivate for installation of ERP	80	C	

Pareto analysis shows that the four type of groups achieved the following score:

A=93, B=93, C=120, D=legal

Where B , C and D are the most affected and need to be improved, first D then B and C.

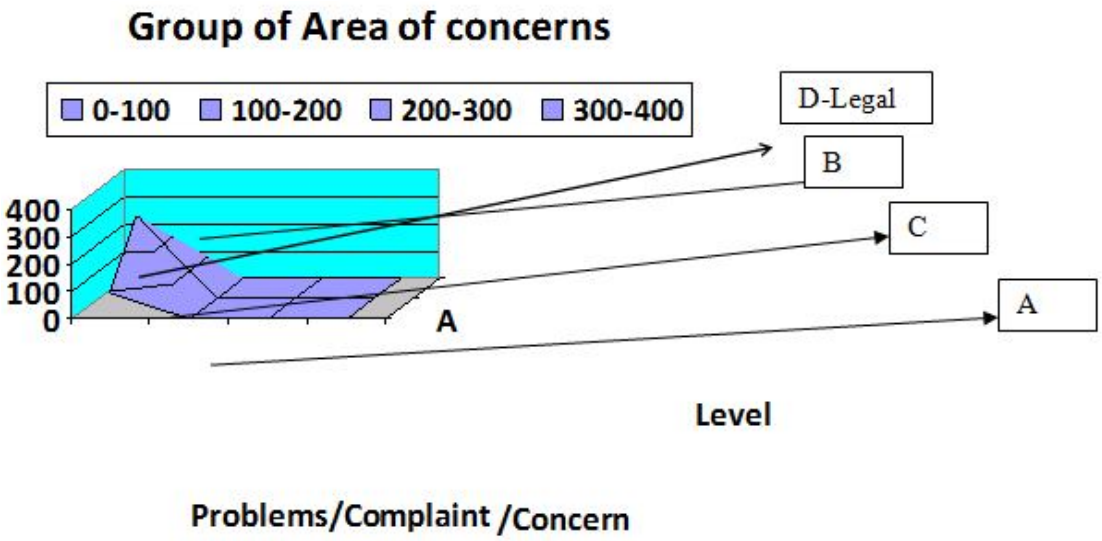


Figure 3. Score of different group areas

B. Project Priority Index Method (PPI) :

Working on the right project is a critical task but PPI helps in prioritizing multiple projects based upon the estimated savings (S) by solving the problem, initial and recurring cost of solving the problem (C), time (T) to complete the project to determine the solution which is ready for implementation, and probability (P) of solving the problem successfully.

PPI = (Saving / Cost) x (Probability / Time) = (S / C) x (P / T)

Table 3. Project priority index

S. No.	Project for Six sigma	Cost expenses	Saving per year	Proba-bility	Time for completion	PPI
Q1	Installation of effluent treatment plant for removal of heavy metals, dyes and other hazardous chemicals	4 Lacks	Human life/legal compliance.	1.0	0.1 year	**10.0**
Q2	Delays control of goods at customer receiving dock by purchasing tempo & extra staff+training+ERP software	Rs. 48 Lacks	Rs. 52 lacs	0. 9	0.3 year	**3.25**
Q3	Loses of ISO 9001 certification by MR	Rs.40000	Rs.14000	0.1	1 Year	**0.035**
Q4	Hiring of Workman for loading/unloading(12 no.s) & training/awareness	Rs.17 Lacks	Rs.20 Lacks	0.3	0.5 year	**1.41**
Q5	Quality controller improvements & system improvements	Rs.15 Lacks	Rs. 25	0.6	0.5 year	**2.0**

In the above root-cause analysis, we found that PPI index of Q1 is more important than the others due to environment concern. Others can be taken in the second phase.

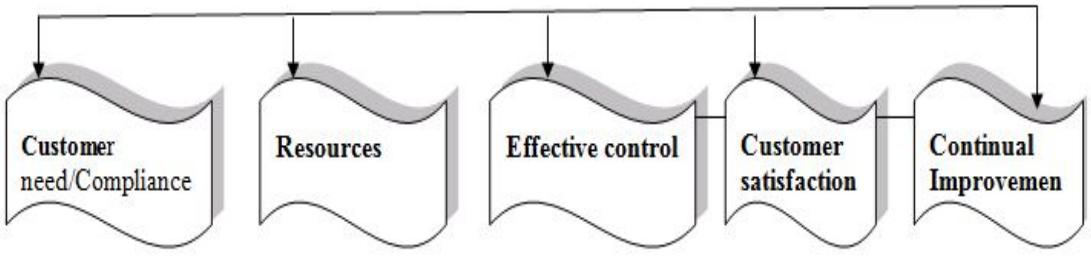
2. Measure Phase

A. SIPOC METHOD :

Table 4. Legal requirements/Goods/parts transfer from factory/logistic department to Customer's dock yard.

Supplier	Input	Requirement	Process	Outputs	Requirements	Customers
i) Effluent treatment for discharge water	i)Effluent treatment plan needs to be installed	i)Discharged waste test results & its control process	i)Treat the waster as per required standards	i)Discharged waster compliant with legal requirements.	i)ETP test results and compare with past history for	i)Save our environe-ment

		ii)Proper	ii)Set up	ii)Goods/parts	further	
ii) Factory Logistic department iii) Finished goods/parts	ii)ERP software installation iii) Tempo purchase iv) Driver hiring v)New staff hiring vi)Training vii) Effective planning & its control vii)Finance	communi-cation, iii)Staff leave plan iv)assign logistic responsibility to other department too v)customer planning sheet vi)New staff	ERP system iii)assign responsibility to resources iv)Enter time sheet for control of ship plan. v)Control all reminders & booking of tempo	reached at customer's dock yard on time	improvement ii) Customer penalty trends. iii)Customer feedback vi)Customer satisfaction level	ii)Goods/ parts purchaser & organization



In the above SIPOC method we installed the effluent treatment plant and reviewed the test results of the treated effluent. and found under legal requirements where as it is confirmed that six sigma improve the environmental concern.

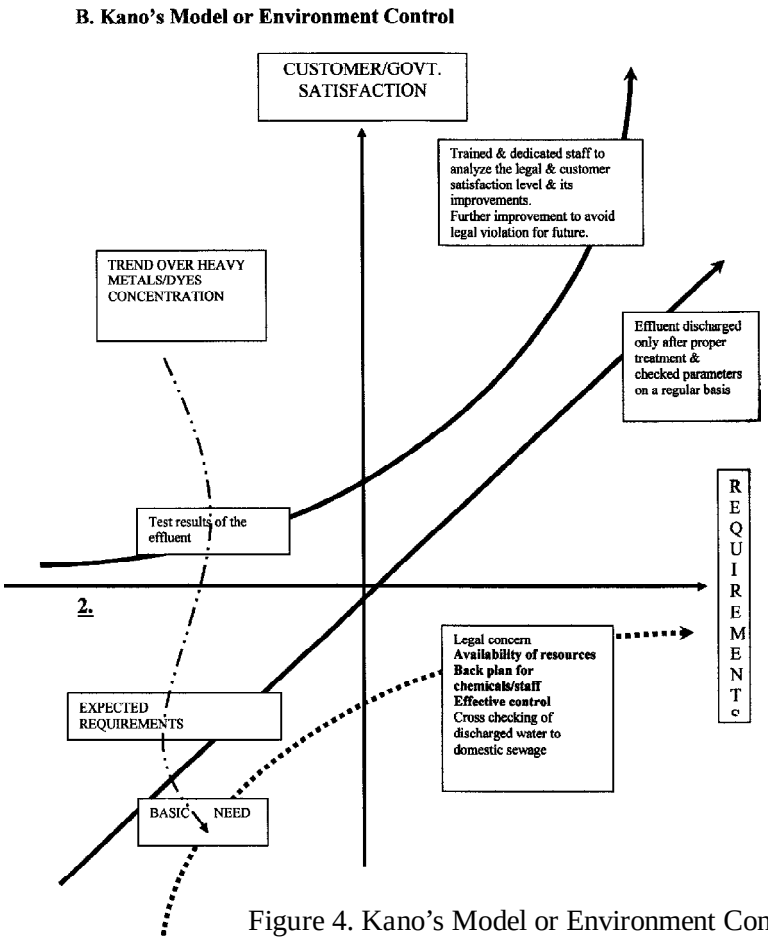


Figure 4. Kano's Model or Environment Control

The above model confirmed the improvement in the quality of waste and its compliance with standards for discharge of the waste.

3. Analyze Phase :

A. Failure Mode and Effect Analysis :

Risk priority number value is to be considered for action and analysis.

B. Process Scope :

Discharged waste water should meet with the standard requirements.

C. Root cause analysis :

The root cause was analyzed and it was found that before installation of the electroplating plant and paint shop no permission was granted from the state pollution control board and no one was aware about the requirements.

4. Improvement Phase :

Table 5. Data Collected After Improvement

S. No.	PARAMETERS	Effluent discharged in last two months
1	Total Discharged waste water	**72 Gallons**
2	Total failure of ETP report	0.280000
3	Six Sigma Rating	4.12
4	Six Sigma rating (Before six sigma project)	1.5
5	Reason of failure to control	The awareness related pollution hazards not know by unit staff.
6	For Further Action	State pollution department has asked to keep monitoring and inform incase of any nonconformities

5. Control Phase

A. Management Review :

The management review of environmental concern is to be conducted initially after 3 months. Management has seen the improvements in the legal related process. However, some money is to be spent to set up the infrastructure and resources hiring process. The following aspects were discussed in the management review meeting:

- Losses to the environment
- State pollution control board feedback
- ETP report on failure and its control
- Sigma rating and DPMO
- Process effectiveness and improvement
- Actions to be taken
- Resources needed

B. Monitoring :

The effluent discharged to the domestic sewage is to be monitored every day and results are to be recorded in data sheet on daily basis for every style/part running in paint shop and electroplating process. Their problems are expected to be resolved immediately. The feedback of their quality of work is to be given to them every month / for every delivery.

Conclusion

Finally it may be concluded that Six Sigma studies at Automobile sector is a potential study which indicates that legal factors (which cause heavy damage to surrounding environment) is much more important and indicates that removal of heavy metals are necessary from the discharge effluent. Six Sigma study for improvement of quality of the process, products and its related factors whereas automobile sectors needs six sigma studies for environmental factor to make our environment free from pollutants.

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