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Lean Sigma A Road to Success: A Perspective of the Indian Automobile Industry

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LEAN SIGMA A ROAD TO SUCCESS A PERSPECTIVE OF THE INDIAN AUTOMOBILE INDUSTRY

Strictly as per the compliance and regulations of:

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Saif Imam [α], Ashok Tripathi [Ω], Sudipto Sarkar [β]

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I. Introduction

Automotive industry is the key driver of any growing economy. It plays a pivotal role in country's rapid economic and industrial development. It caters to the requirement of equipment for basic industries like steel, non-ferrous metals, fertilizers, refineries, petro-chemicals, shipping, textiles, plastics, glass, rubber, capital equipments, logistics, paper, cement, sugar, etc. It facilitates the improvement in various infrastructure facilities like power, rail and road transport. Due to its deep forward and backward linkages with almost every segment of the economy, the industry has a strong and positive multiplier effect and thus propels progress of a nation.

The Indian automobile industry at present is experiencing an unprecedented boom in the demand for vehicles of all types. This boom has been primarily stemmed from two major factors; firstly, because of the rise in the disposable incomes and the standard of living of the middle class Indian families and secondly due to the Indian government's liberalization measures such as relaxation of the foreign exchange and equity regulations, reduction of tariffs on imports, and banking liberalizations. Industry watchers have predicted that the passenger vehicle sales will triple in the next five years to about one million, and as the market grows and the customer's purchasing abilities rise, there will be greater demand for high-end luxurious models also which currently constitute only a tiny fraction of the market. These trends have encouraged many giant multinational automakers to enter the Indian market. This is just one face of the coin. To get a better idea let us take a brief history of the Indian Automobile Industry.

a) *History of the Indian Automobile Industry*

For several years after India's independence from the British in 1947, the Indian car market was dominated by two localized versions of ancient European designs -- the Morris Oxford, popularly also known as the Ambassador, and an old Fiat. This was mainly due to the Indian government's complex regulatory system that effectively banned foreign-owned operations. Within this system, any Indian firm that wanted to import either technology or products needed a license from the government. The tedious process of obtaining these licenses stifled automobile and component imports. As a result of this, the Indian automobile industry had become a low volume and high cost car industry that was not only inefficient and unprofitable, but also technologically obsolete. Pingle (2000) reviews the policy framework of India's automobile industry in which he stated that the Indian Government was characterized by socialist ideology resulting in protection to the domestic auto industry and entry barriers for foreign firm between 1940's and 50's. During the next phase of rules, regulations and politics, the Indian auto industry was affected by many political developments and economic problems especially for passenger car segment. This is the period between in 1960' and 70's. In the early 1980's considering it as a third phase it was characterized by delicensing, liberalization and opening up of FDI in the auto sector. Narayanan (1998) analyses the effects of deregulation policy on technology acquisition and competitiveness in the Indian automobile industry during the 1980s and finds that competitiveness has depended on the ability to build technological advantages, even in an era of capacity-licensing. These policies resulted in the establishment of new LCV manufacturers. In the early

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1980's, the Indian government made a few efforts, all though limited, at reforming the automotive industry and thus initiated a joint venture with Suzuki of Japan. This landmark joint-venture called Maruti Udyog Limited launched a small but fuel efficient model priced at about $5,500.This new product perfectly caught the fancy of the Indian people and became an instant rage. In 1991, the government further initiated a series of economic liberalization measures designed make the Indian economy porous to foreign investment and trade. In 1993, the Indian government brought a wave of FDI to India's vehicle industry. Import barriers have been progressively relaxed. Today, almost all of the major global players are present in India. The automotive industry is today a key sector of the Indian economy and a major foreign exchange earner for the country. The government further followed up its earlier liberalization measures with significant reductions in the import duty on automobile components. As a results of these measures, the automotive industry experienced growth rates of above 25% which have been increasing since.

b) Present Scenario and scope for future

Based on the data available at Business portal of India, India is the world's second largest manufacturer of two wheelers, fifth largest manufacturer of commercial vehicles as well as largest manufacturer of tractors. It is the fourth largest passenger car market in Asia as well as a home to the largest motor cycle manufacturer. The installed capacity of the automobile sector has been 9,540,000 vehicles, comprising 1,590,000 four wheelers (including passenger cars) and 7,950,000 two and three wheelers. The sector has shown great advances in terms of development, spread, absorption of newer technologies and flexibility in the wake of changing business scenario. In the past two years, a number of multi-national firms have announced plans to enter the Indian market.

Besides, the announcement of 'Automotive Mission Plan' for the period of 2006-2016 is a major step taken to make India a global automotive hub. The Mission Plan aims to make India emerge as the destination of choice in the world for design and manufacture of automobiles and auto components, with output reaching a level of US$ 145 billion (accounting for more than 10% of the GDP) and providing additional employment to 25 million people by 2016. It envisages increase in production of automotive industry from the current level of Rs. 169000 crore to reach Rs. 600000 crore by 2016. McKinsey (2005) predicts the growth potential of India-based automotive component manufacturing at around 500 per cent, from 2005 to 2015.The Mission seeks to oversee the development of the automotive industry, that is, the present scenario of the sector, its broad role in the growth of national economy, its linkages with other key facets of the economy as well as its future growth prospects. This is involved in improving the automobiles in the Indian domestic market, providing world class facilities of automotive testing and certification as well as ensuring a healthy competition among the manufacturers at a level playing field.

The future challenges for the Indian auto industry in achieving the targets defined in the Automotive Mission Plan would primarily consist of developing a supply base in terms of technical and human capabilities, achieving economies of scale and lowering manufacturing costs, as well as overcoming infrastructural bottlenecks. While, the role of industry is primarily of designing and manufacturing products of world-class quality standards, establishing cost competitiveness, improving productivity of both labour and capital, achieving scale and R & D enhancing capabilities as well as showcasing India's products in potential markets.

As can be inferred from the literature, the emergence of foreign companies into the Indian market will lead to a tough competition amongst the indigenous companies to remain in the market. The need of the hour in today's highly competitive global economy requires even the most well established manufacturers to continuously improve their quality while reducing costs. This has become an essential for their survival. With the tight budget constraints and cost cuts, producing more with less has become the key to market leadership and sustainable competitive advantage. Changing production methods from mass production with high inventory to a leaner operation with low inventory has become an essential for successful manufacturers. As the concept of Lean six sigma satisfies both cost and quality constraints related to both products and services, many organizations would want to adapt the same.

II. Literature Review: Lean Sigma

The concept of mass production was established in the early 19^{th} century by Henry Ford (1913). This formed the building block for systemization of Lean production. Later in the century, at the end of the Second World War, the scarcity of resources coupled with intense domestic competition in the Japanese market for automobiles led to further innovations. Taiichi Ohno (1988) a former executive vice president of Toyota furthered the concept of Henry Ford and focused on the elimination of waste and tailored a more efficient production system according to the need of the Japanese market. Initially during the 1950's, this work was applied basically to car engine manufacturing followed by vehicle assembly in the 1960's and then to wider supply chain. This production philosophy was widely known as the Toyota production system in Japan. It was only in 1986 that Womack and Jones (1990) labeled it as "Lean Production and Lean thinking". The term Lean was used by John Krafick (1988) to describe the new production techniques that were used at Toyota.

The five key principles of Lean as identified of Lean Thinking given by Womack and Jones (1996) include:

1. Elimination of waste (or muda in Japanese);
2. The identification of the value stream;
3. The achievement of flow through the process;
4. Pacing by pull (or kanban, a Japanese term) signal;
5. The continuous pursuit of perfection.

According to Womack and Jones (1990) Lean refers to the total enterprise, from the shop-floor to the executive suite and from the supplier to customer value chain. It optimizes the skills of the workforce by encouraging continuous improvement activities and aims at achieving perfect value by the elimination of waste. By the application of Lean processes, an organization basically aims at being able to manufacture a large variety of products of high quality at a lower cost within a lesser time and with less investment. Between late eighties and early 90's lean concentrates on the shop floor. Later in the 1990's, Lean had moved away from a "shop floor focus" on waste and cost reduction to a more customer centric approach, where it tried to increase value to customers by adding product features and eliminating wasteful activities linked to customer requirement. Lean is defined by Womack and Jones (1994) as the systematic removal of waste by all members of the organization from all areas of the values stream. Kannan and Tan (2005) have referred Lean as a cost-reduction mechanism, which strives to make organizations more competitive in the market by increasing efficiency, decreasing costs incurred due to elimination of non value-adding (VA) steps and inefficiencies in the processes, at the same time simultaneously reduces cycle times and increases profit for the organization. This is achieved by identifying and removing wasteful activities with the help of the tool known as value stream mapping in lean terminology. With the help of this, analysis can also be done on the activities in the process. Value stream represents the "flow of value" to these organizations. Worley and Doolen (2006) made an analysis primarily based on identifying activities that add value to the product or activities. They classified this as muda- the Japanese word for waste. Kannan and Tan (2005) also found that waste can be found in all activities in the value stream, especially where the product moves from one department to another. Taj and Berro (2005) claimed that many manufacturing companies waste over 70 percent of their resources. Jones et al (1997) examined that for many organizations, less than 10 percent of activities often are value adding and as much as 60 percent do not add any value at all. Similarly, Bhasin and Burcher (2006) identified that implementing Lean can reduce waste by 40 percent and recognized seven typical forms of waste as overproduction, waiting, transportation, inappropriate processing, excess inventory, unnecessary motion, and defects. According to Claycomb et.al. (1999) the lean system promotes conditions necessary to manufacture high quality products to meet market demand with relatively small levels of inventory. Here, holding costs can be diminished by ordering the materials whenever needed and producing the items as per the forecasted demand. As a result, "companies have substantially cut lead times, drastically reduced raw material, work-in-process and finished goods inventories, and effectively increased asset turnover".

Brady and Allen (2006) reviewed that Six Sigma concepts were developed at Motorola through the efforts of Bill Smith, a reliability engineer, in the 1980s. This method was adopted by many US Companies, including GE and Allied Signal. It was in fact through the work of Jack Welch, the CEO of GE in 1995, that Six Sigma found its popularity amongst companies. The term "Six Sigma" refers to a statistical measure of defect rate within a system. This typically presents a structured and systematic approach to process improvement, aiming for a reduced defect rate to 3.4 defects for every million opportunities. Pande et.al. (2000) stated six sigma is a strategic, company-wide approach which helps in reducing costs of a project and increasing customer satisfaction by focusing on reducing variations. George (2002) reviewed that six sigma uses tollgate at the end of each phase. These five tollgate or phases are: define, measure, analyze, improve, and control (DMAIC). This DMAIC methodology is designed specifically for improvement of existing processes which helps in reducing costs of a project and increasing customer satisfaction by focusing on reducing variations. Pojasek (2003) mentioned using statistical methods, organizations are able to understand fluctuations in a process, which allows them to pinpoint the cause of the problem and subsequently help in improving the process by eliminating root causes, and controlling the process to make sure that the defects do not reappear. According to Sower et.al. (1999) the root of six sigma lies in the concept of total quality management where everyone in an organization is responsible for the quality of goods and services produced by the organization. Apart from this, the other components of Six Sigma that can be traced to Total Quality Management (TQM) include the focus on customer satisfaction when making management decisions, and a significant investment in education and training in statistics, root cause analysis, and other problem solving methodologies.

Lean Six Sigma is a widely applied program for company wide quality improvement. It is the synthesis of Six Sigma and Lean. Using one of these tools has limitations. Since lean eliminates the use of Six Sigma's DMAIC cycle on the other hand, Six Sigma eliminates defects but does not address how to optimize the process flow. Hence, applying both Six Sigma and Lean tools sets results in far better improvements than could be achieved with either one method alone.

III. Methods and Meth

Based on an extensive research of the available data 5 major automobile industries in and around the Indian capital were shortlisted. After obtaining due permission from the concerned authority a survey was conducted. This survey was based on the individual visits to the shop-floor in order to understand the manufacturing processes involved in each industry. Along with this a detailed subjective interview of the employees of these industries was conducted. The employees interviewed belong to different levels of the industrial hierarchy from shop floor technicians to the production managers. Further details about the operating processes was obtained from the officially available data in the form of magazines and the other brochure of the companies. From the information collected on the basis of aforesaid sources the following details were collected.

a) Major Components of Production Division

Major Components of Production Division in the Automobile Industry are; Press Shop and Blanking Line, Weld Shop, Paint Shop, Engine Assembly, Assembly Shop, Machine Shop Materials, Casting, Engine, Vehicle Inspection.

Press shop : Press shop can be regarded as the starting point of the car manufacturing process. The weld shop as per the requirements picks the finished body parts from the press shop. These may be sub divided as according to size of blanks. Like 'A' components are large outer components as for example roof, door panels etc. Press Shop produce sheet metal components for different models.

Press shop has Press machines it can be according to the capacity of the press shop ranging from 4000 ton to 22000 ton in terms of total capacity i.e. draw, trim, pierce, bend, re-strike & 1 Tandem line. Coil processing lines (ROSL – Shear line & Blanking line). Capacity can be of 55,000 strokes / day from 400 tons of steel coils. Mass production presses are continuous flow transfer presses. Set of 4 to 5 dies are mounted on single press & complete panel comes out from press after going through stamping, trimming & piercing. Steel coil which are CRS coils made up of mild steel is a raw material used to make body sheet metal parts. Its thickness ranges from 0.65 mm to 0.8 mm & weight from 1 ton to 4 tons. Steel coils are received in bulk quantities & stored at a centralized storage & supplied to blank cutting areas as per plan. Steel coils are fed to Blanking & ROSL lines by overhead EOT cranes. Sheet is first de-coiled, cleaned, oiled & fed to cutting or shearing areas of blanking or ROSL lines. Coils are fed to blanking line & continuous supply of sheet to cutting dies result in shaping of coils to plan blanks. Blanks are cut by stamping or shearing process & are stacked one by one to form large mass of blanks. The stacks of blanks are further sent to press machines for forming into shape of body panels. Blanks are supplied to press lines for pressing. Blanks are converted to body panels by this process. Panels are stored in pallets which are supplied to Weld Shops for making White Bodies.

Fig.1 : Shows the cutout panels are stacked properly together in a trolley in order to maintain 5-S culture.

Types of Panels

1. External (skin) panels, such as fenders, bonnet, decklid, roof, side panels, doors, etc. Some of these are two panels in a set as left hand and right hand
2. Internal mating panels, such as bonnet inner, decklid inner or door inner deciding subassembly quality
3. Dimensionally critical inner panels that are complicated either because of their complex shape or severe draw condition, such as, floor pans, dash panel, etc.

Fig.2 : A completed panel after press work

The body panels produced in the press shop and the other small components are joined here to give the "white body" or "shell". In a typical car body 1400 different components are welded together. The weld shops should have the following facilities; Welding jigs, Spot welding guns, welding robots, hemming machines, punching machines. The weld shop has different lines for different models, each of, which is further divided into three parts:

1. Under Body: Here different underbody panels are welded together. These comprise of rear underbody, central underbody and front engine room panel. These underbodies are put on the conveyor and welded together to give the underbody.
2. Main Body: As the body moves on, the conveyor roof and side body panels (prepared on the sub lines) are welded to it to give the main body. The chassis number is punched on the cowl top and it is welded to the front engine room panel.
3. White Body: The doors, hood and back door are attached on the main body with the help of bolts and screws to make it a "white body". The body is checked for dent, burr and spatter and these defects are repaired. It is sent to the paint shop thereafter.

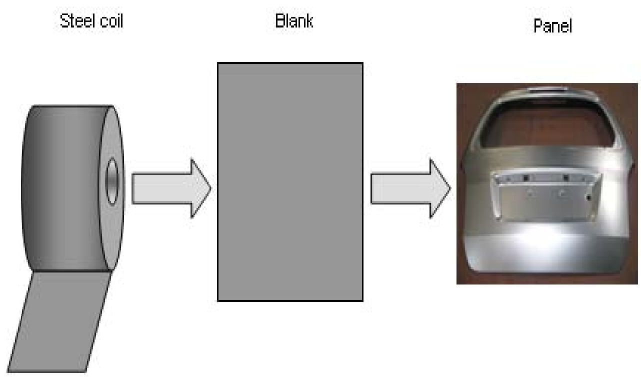

Fig.3 : Shows how steel coils are being cut before converting it into the panel

Paint Shop:

In the paint shops following processes are carried out; there are five plants/units that provide a uniform painting over the white body coming from the weld shop. In paint shop all the models are painted on the same line. Inside portion of vehicle is painted manually and outside is by Robots. After inspection and touch up the ready body is sent to the assembly shop.

The five units of the paint shop are;

1. Pre-treatment (PT): The body is thoroughly washed to remove the dirt and oil scales. Then the body is phosphate treated to prevent corroding of the body.
2. ED coat: This is done by electric deposition method, at 240V-DC supply. After applying the ED coat the body is baked in oven.
3. Sol-sealer and under coat: Here the holes left in the body (due to welding) are filled with sol-sealer to provide water proofing. Under coat is done on the surface above wheels to prevent damage of body in that portion.
4. Intermediate coat: This is done by spray-painting method using Robots. Here also inside painting is done manually. After applying the coat, the body is dried in the oven. Painting done is basically an intermediate coating to provide base for the final coat. Paint thickness is taken care, after that vehicle is sent to IC oven. Oven temperature is 198+/-5'C.
5. Top coat: This is done by spray-painting method using Robots. For metallic coating, double coats are applied and aluminum flakes are provided to shine the metallic paints. Top coating is done after inspecting dry sanding. After this the vehicle will move to final inspection and will be sent to assembly shop.

Assembly Shop:

In the assembly shop the body is loaded on an overhead conveyor. As the conveyor moves the body, fitments are made at various stations. There must be separate assembly lines for separate models. The assembly shop has a continuous production system. The assembly line can be subdivided into the followings;

1. Trim line

The vehicle proceeds through a series of Trim workstations where team members begin by installing weather stripping, moldings and pads. Then they put in wiring, vents and lights. After an instrument panel, windows, steering column and bumper supports are added, it starts to look less like a shell and more like a car.

2. Chassis Line

This is where many safety-related items are installed. Things like brake lines, torque, gas tanks and power steering are double-checked. The engine is installed, along with the starter and alternator and then comes suspension and exhaust systems. After that wheel is mounted with the help of wheel nut fastening machine.

3. Final Line

From there the vehicle enters Final 1, which covers many interior items such as the console, seats, carpet, glove box and steering wheel. This is also where bumpers, tires and the battery are added, as well as finishing touches like covers and vents. Then, Coolant, Brake oil, Power steering oil are filled and also the A/C gas are charged.

3. Separate door Assembling Line

Doors are taken out from the vehicle at the first station of the trim line. Doors fitted in the final line make working easier.

Machine Shop:

The machine shop is the source of all major components for the engine assembly shop. It has the following lines; Transmission case line, Cylinder head line, Cylinder block line, Crankshaft line, Camshaft line. The un-machined crankshaft and camshaft forgings, transmission case cylinder head and cylinder block castings are brought in the form of raw materials from the vendors. The cylinder heads and transmission case are aluminum castings while crankshaft and camshaft are steel forgings.

Engine Assembly:

There can be many different types of engines which are assembled in the Engine Plant for petrol and diesel engines. FC Engine, aluminium engine, KB engines etc are the different engines.

Generalize Process Flow Chart

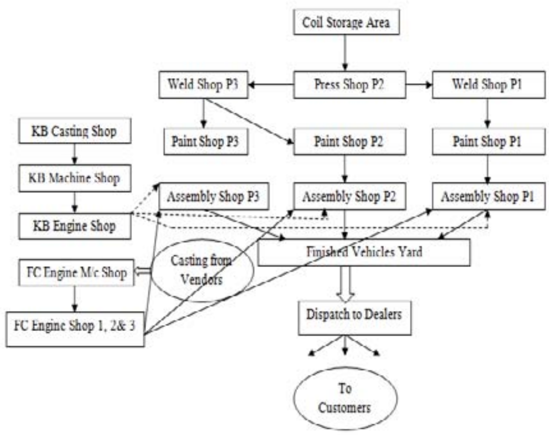

Fig.4 : Indicates the generalize process flow chart based on the survey showing the flow of material from one process to other

The results of the survey also shows that in the press shop the main challenge of any automobile manufacturer is reducing the scrap rate of sheet metal or increasing the utilization ratio. In this shop the aim is to save the sheet metal to go into the scrap so that money can be saved. One of the method that most of the company do not adopts is to use blank cutout of large panels as raw material for making small parts that has to be used in press machine otherwise it will go into scrap. Wastage control can also be done in the following manner:

Wastage Control

1. Residual flat parts (scrap) utilization
2. Die Face Modification
3. Reducing the Blank Size by Gauge Adjustment
4. Changing the Blank Shape
5. Modification of the Punch Profile
6. Modifying the Bead Design

Table 1 depicts the different tools pertaining to cost quality issues and their application areas within the automobile production and assembly lines. The survey of automobile manufacturing units in the research generalises the facts about the tools used in the manufacturing premises at different automobile industries.The different tools that are used in automobile industry is an important factor to cost and quality issues.

Based on the visits to manufacturing premises and interviewing at different levels from the shop floor technicians to managerial representatives the common defects that come into the picture that lead to rework are shown in Table 2. In context with the processes involved in the automobile line the following defects may occur in the processes listed below;

Table1

Tools	Category/ Belongs to	Application Area
5S (Sort, Set in order, Shine, Standardize, Sustain)	Lean	Everywhere in the organization
Quick Change over/ SMED	Lean	Press Shop
Fishbone Analysis	Lean	Press , paint, weld & machine shop
Value Stream Mapping	Lean	All processes starting from raw material to finished product
Mistake Proofing	Lean	
Waste identification and elimination	Lean	All the shops
Setup time reduction	Lean	Press Shop, machine shop
Inventory reduction	Lean	Store, in process, stock at last
Yield improvement	Six sigma	Blanking operation
Wastage Control	Six sigma	Scrap utilization at press shop
Avoiding any type of rework	Six sigma	All the shops
Mistake proofing	Lean/Six sigma	All the shops

Table 2

S.No	Process	Defects	Precautions
1.	Blanking operation	Excessive deformation *Surface defects*: cracks and necking *Form Defects*: wrinkling and marking lines	(i) Too much clearance
2.	Weld shop	Spot Welding: Improper squeezing, splashing , burnt surface conditions, electrode pick up, copper deposits in the weld area and excessive electrode wear, in-sufficient energy, over energy	(i) Proper setting squeeze time, proper setting of weld time, forge time, forge force, peak force
		Metal Inert Gas Welding: Porosity	(i) Gas flow too low or too high (ii) Blocked nozzle (iii) Leaking gas lines (iv) Nozzles distance from work is too great (v) Wet or rusty electrode/wire
		Lack of penetration	(i) Current too low (ii) Worn contact tip causing irregular arc (iii) Incorrect alignment of plates
		Lack of fusion	(i) Voltage too low (ii) Current too low or too high (iii) Irregular surface
3.	Paint Shops	Runs: (i) Incorrect spraying viscosity, spraying technique, flash-off times between coats, and film thicknesses (ii) Incorrect spraying pressure (iii) Temperature of paint, substrate or spray booth too low (iv) Incorrect choice of hardeners and Thinners	(i) Follow application recomm-enddation on technical data sheets (ii) Warm object and material up to room temperature of 20 °C/68 °F (iii) Use correct combination of hardeners and thinners
		Adhesion problems between base and clear coats: (i) Excessive coat thickness of basecoat (ii) Intermediate and final flash-off times of the basecoat too short (iii) Wrong mixing ratio of clearcoat/ hardener (iv) Incorrect hardener/thinner combination; system too fast	(i) Use the intermediate and final flash off times from the technical data sheet (ii) Choose and mix clear coat, hardener and thinner according to technical data sheet
		Lifting and Wrinkling: (i) Occurs when chemical reaction takes place between two incompatible substrates (ii) High film builds (iii) Overcoating an uncured substrate (iv) Wet-on-wet system combined with incorrect hardener/thinner	(i) Avoid working on high film thicknesses (ii) Ensure all products used are part of are finish system (iii) Allow materials to flash off and dry in accordance to technical data sheets (iv) Use recommended hardener/thinner combination

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IV. Proposed Lean Sigma Model: An Outline for Lean Sigma Execution

An outline is proposed to implement to Lean Sigma in the organization as shown in figure 5.The framework is developed, after a number of meetings with top and middle level management and the facilitators are carefully considered in the whole process. This helped to develop the Lean Sigma outline for implementation on the shop floor. In the proposed framework, Lean tools are used within the Six Sigma (DMAIC) problem-solving methodology to reduce the defects occurring in the ending product.

Define

Establishment of the rationale for a Lean Sigma project. Define the problem to be solved, including customer impact and potential benefits.

Measure

Identify the critical-to-quality characteristics (CTQs) of the product or service. Verify measurement capability. Baseline the current defect rate and set goals for improvement. This phase is concerned with selecting one or more product characteristics; i.e. dependent variables, mapping the respective process, making the necessary measurements, recording the results on process "control cards," and estimating the short- and long-term process capability

Analyze

Understand root causes of why defects occur; identify key process variables that cause defects. Benchmarking the key product performance metrics. Following this, a gap analysis is often undertaken to identify the common factors of successful performance; i.e. what factors explain best-in-class performance. Analyze the preliminary data collected in the Measure phase to document current performance (baseline process capability), and to begin identifying root causes of defects and their impact, and act accordingly.

Improve

Determine how to intervene in the process to significantly reduce the defect levels. Generating, selecting, and implementing solutions.

Control

Implement ongoing measures and actions to sustain improvement. Once the desired improvements have been made, put a system into place to ensure the improvements are sustained, even though significant resources may no longer be focused on the problem.

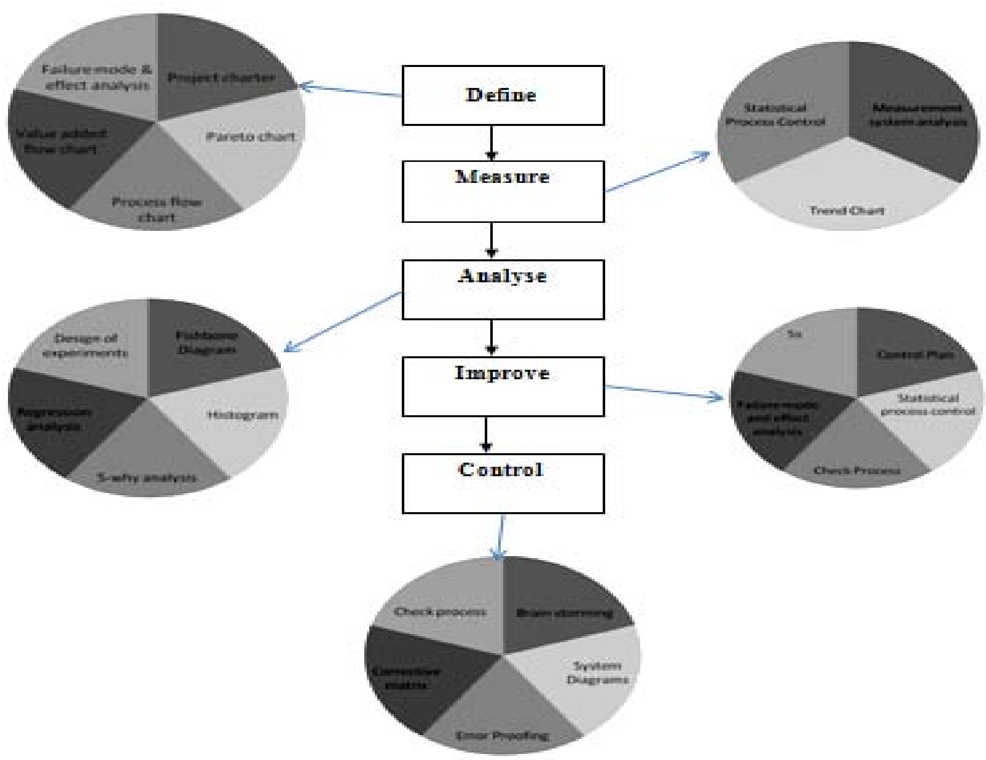

Fig.5 : Shows the proposed model for lean six sigma implementation

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V. Conclusion

After a brief review of the history and a detailed analysis of the current state of the Indian automobile industry, it can be concluded that in order to stay ahead of competition and as well as meet the ever growing demands of the consumers, the industry needs to adapt newer measures for increasing productivity by eliminating waste and avoiding rework . This paper aims at doing so by introducing the concept of lean six sigma as an effective cost cutting tool. It also proposes a lean six sigma model for the effective lean sigma execution in the automobile industry. The author wishes to conclude by stating that the lean sigma model holds significance not only in the Indian context but can also be considered to be a global solution for the problems related to cost, quality, waste elimination, rework and productivity as a whole.

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