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How Indian Automotive Companies Can Achieve World Class Quality Through Closed Loop Quality Management System- An Analysis and a Recommendation

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Abstract: ***The aim of the research was to understand the quality maturity of Indian organization (especially automotive OEM & Tier-1) and recommend steps how they can achieve world class quality through implementation of closed loop quality with a change mindset of "Quality is everyone's responsibility" and "Quality should be built-in and not inspected".***

Keywords: ***About four key words or phrases in alphabetical order, separated by commas.***

I. INTRODUCTION

EXECUTIVE SUMMARY

1.1. INDIAN AUTOMOTIVE INDUSTRY

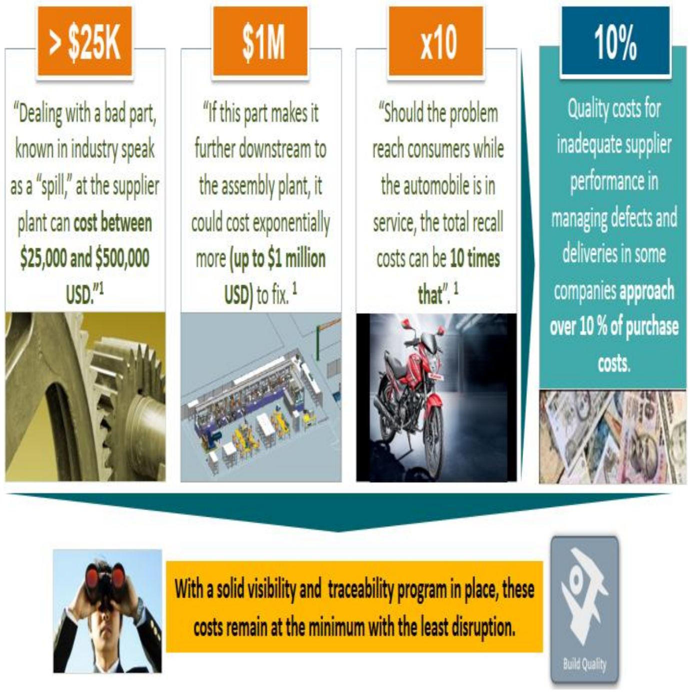
In year 2017, the Indian automotive industry became 4th largest in the world. The same year India became the 7th largest commercial vehicle manufacturer. The two wheelers dominate the automotive market in terms of number of vehicles sold. A young population, growing middle class and rural market has been fueling the growth the two-wheeler market. The growth is not only expected from domestic consumption but also from India's prominence from export of the automotive vehicles. To compete in international market the Indian automotive companies need to be on par with the international brands specially from countries like German, Japanese and Korean.

1.2. WHAT IS QUALITY?

"Quality in a product or service is not what the supplier puts in. It is what the customer gets out and is willing to pay for. A product is not quality because it is hard to make and costs a lot of money, as manufacturers typically believe. This is incompetence. Customers pay only for what is of use to them and gives them value. Nothing else constitutes quality." – Peter F Drucker

1.3. WHY IS SUPPLIER QUALITY IMPORTANT?

With more than 80% of parts from Supplier, Supplier plays an important part in the overall quality of the vehicle. Failure to collaborate effectively, especially in Quality, may have severe business impact.



Source: 1 Larry Graham, global manager for manufacturing technology at General Motors

As per a report if a problem is defect or bad part is found out at the supplier plant, it can be fixed be fixed or the cost to fix the same is between 25k USD to 500k USD, but when the same parts makes to the production assembly line, to fix the same raises exponentially to a million-dollar USD. The impact grows multiple fold if the product with bad/defected part/component reaches consumers.

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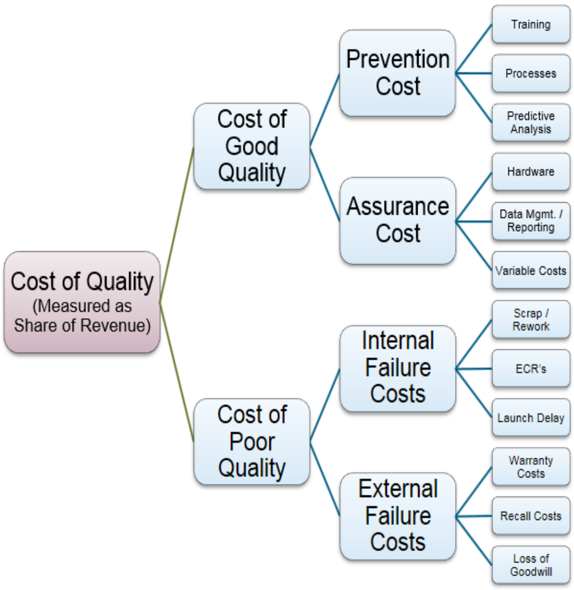
1.4. COST OF POOR QUALITY

Quantifying cost of Quality or Cost of Poor Quality is a very involved topic. Our Experience shows that in India very few companies measure data related to the Total Cost of Quality.

The cost of quality can be basically broken down into two categories:

- **Cost of Good Quality** - The money spent on preventing problems and checking quality
- **Cost of Bad Quality**- The money companies pay for the failures and damages.

An example: a poor locator design for transmission mount, would've cost a few hours to fix in design, could cost a couple of hundred thousand dollars to fix in ramp up, and would cost millions of dollars or a lot more in warranty and recalls. There are many real-world examples. (Click) As you can see the cost of poor quality is a lot more expensive than cost of good quality, and the smart money is shifting left to achieve affordable quality.



The below table elaborates the different type of costs:

Type of Cost	Process	Example
Prevention Costs	Quality Management Processes, i.e. APQP/PPAP	• "The (NA) automotive industry spends $8B/Yr moving quality documents through the supply chain" • In North America alone approximately 10,000 automotive related suppliers generate between 2.9 and 4.1 million PPAPs, costing the industry approximately $6.2 billion annually in supply-chain labor costs
	Dimensional Management	• Recreation of data throughout the process • Inefficient design reviews • Inefficient communication
Assurance Costs	Cost of unnecessary measurements	• "Adding a measurement point costs $5k" –NA OEM estimate • 90% of out of spec points (that had to be fixed) had no impact on assembly quality
	Cost of locating data	• Typically, at least as much time is spent locating dimensional data as is spent analyzing it
	Cost of non-interoperable systems	• Estimated throughout the NA automotive industry as being between $600M and $1B/yr
Internal Failure Costs	Scrap / rework	• Harbor report 2006 press release: "The manufacturing productivity gap among North American automotive manufacturers is smaller than ever as quality advances are driving productivity improvements and all manufacturers get more from their work force and capital investments…"
	Engineering Change Requests	• Increased ECR costs due to not following good Dimensional Management practices estimated to be at least $21M/program • Unnecessary die changes (that have no effect on end quality) $12.5M/program
	Launch delays	• Launch delay costs > $1M/Day • Ford delays Explorer launch by 6 months due to "normal quality and fit and finish issues". • Increased launch timing due to not following good DM practices estimated to be 2 months
External Failure Costs	Warranty costs	• For example, 2006 warranty costs for US publicly listed companies = $28.2B (1.65% of product revenue) • 2006 Warranty costs for GM is $4.5B (2.6% of product revenue) for Ford is $4.1B (2.9% of product revenue)
	Product recall costs	• For example, ~2.75M vehicles recalled in the US in Q1 of 2007 ○ Assuming cost of $75/vehicle this equates to $825M/year • Business week estimate that recalls, and resulting production delays, cost Ford $1B in 2000/1

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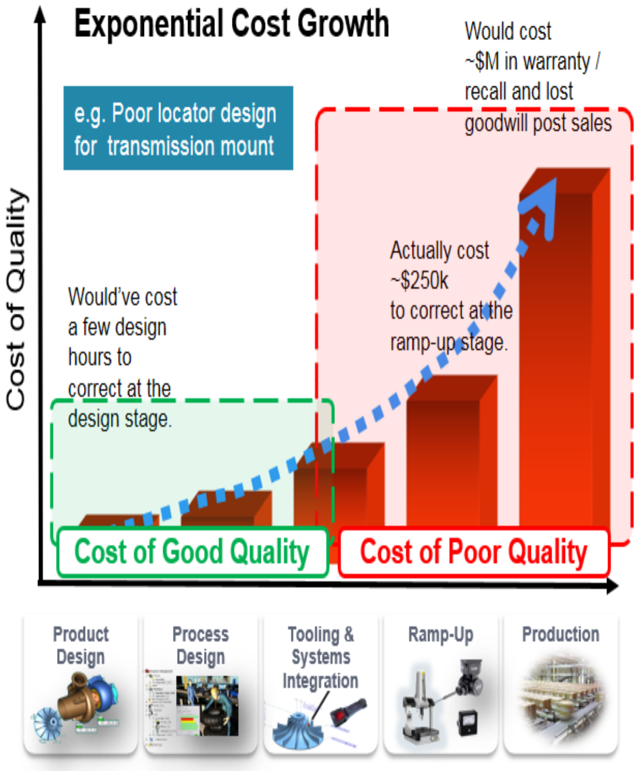
	Gain/loss of customer goodwill	• From # of vehicle recalls: ○ # of recalls, 1999-2007: Ford (1631), Chevy (1566), Toyota (398) • JD Power Surveys: ○ JD Power surveys indicate that initial quality has to improve at approximately 4-5%/year to maintain the same competitive position • Craftsmanship levels ○ SPLM competitive assessment data indicates that an OEM has to improve fit and finish quality at the rate of approximately 2%/year to maintain the same competitive position

The diagram below depicts:

1) cost of achieving desired quality consist of "Cost of Good Quality" and "Cost of Poor Quality" is measured as share of revenue that direct impacts business bottom line;

2) manufacturers must work proactively to "shift left" from "cost of poor quality" to "cost of good quality" in order to achieve Affordable Quality.



"Cost of Poor Quality" is usually incurred due to reactive business process and actions, while "Cost of Good Quality" is to proactively catch quality escapes as early in the process as possible.

II. Assessment of Current Quality at Indian Automotive Companies

1.5. Assessment of Quality Maturity Index of Indian Automotive Companies

One of the survey which I have used in Quality Assessment Event which was jointly hosted by CII and my company SISW. This was to assess the current quality maturity assessment. The event was conducted in three different cities – Pune, Gurgaon and Chennai. People from various organizations participated in the same. Please refer appendix A for the same. The results for Pune event is also presented.

A set of questionnaires was prepare based on Deming Cycle of Plan, Do, Check & Act (PDCA) and hosted online for participants.

Plan - involves analyzing the status, developing improvement potentials and the compiling conceptual realization. Solution areas covered under Plan stage of Deming cycle includes: Program Management, Design for Quality, Dimensional Variance Analysis, Failure Modes and Effect Analysis (Design, Process), Process Flow Chart, Inspection Plan, Control Plan, PPAP, Compliance to Standards (including IATF:16949, IS, APQP, VDA)

Do - embodies the practical realization of the concept, which is tested on a small scale using simple means and test equipment. Solution areas include - Incoming & Outgoing Goods Control, Industrial Recognition & Identification (Traceability), Production Monitoring & Supervision, Inspection Execution.

Check - generates and checks results of the test run and sets the standard and includes process areas likeStatistical Process Control, Supplier Quality Management, Dimensional Validation, Defect Tracking and Non-Conformance Management

Act - the last phase, involves wide-scale implementation of the new standard and regular monitoring through audits. It includes Audit Management, Issue Management & CAPA, Compliant Management, Quality Dashboards & KPIs

The option to be selected were divided broadly into five categories as below:

- L1 - Paper-Based; Manual
- L2 - Spreadsheet
- L3 - Digital Capture of data
- L4 - Online Solution
- L5 - Connected, Integrated Solution

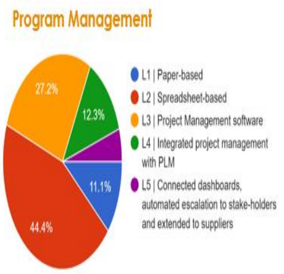
1.6. Results of the Online Survey at the Event

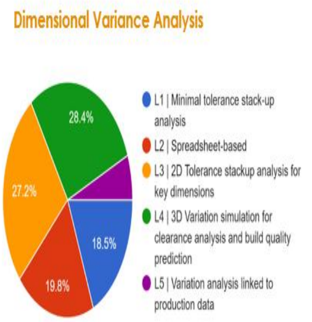
1. Plan Stage

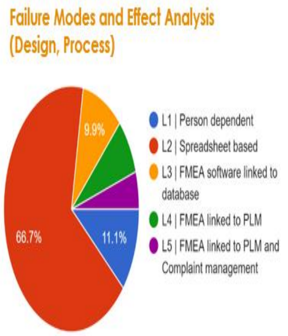
The survey in all three cities showed that most of more than 40% of the companies use excel spread sheet for program and project management. Less than 6% organization leverage the benefits of deliverable based program management using enterprise application like product lifecycle management (PLM).

For design for quality majority of the organization have some form of digital document management with workflow. While the organization maturity is high in case of dimensional variance analysis. Companies benefits by using digital 2D and 3D models for the variation analysis.

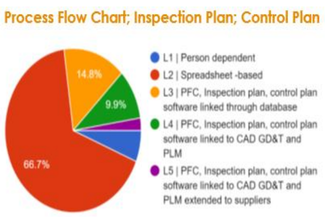
For Risk Management like Design FMEA (DFMEA) and Process FMEA (PFMEA), organizations do understand the preemptive measure for better quality but the same are done still in xls spreadsheet. While ideal condition for example would have been connected DFMEA -> PFMEA -> PCP (Process Control Plan).

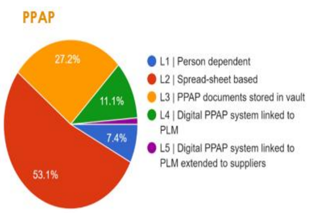


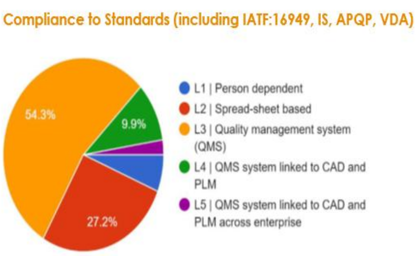




Automotive companies in India do have adopted the IATF 16949 (previously known as TS16949) but the prime source of data collection and report generation have been Microsoft excel.

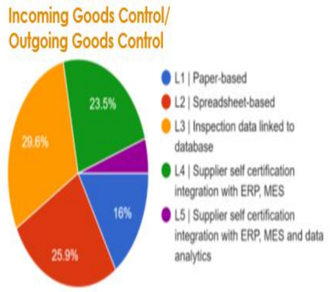


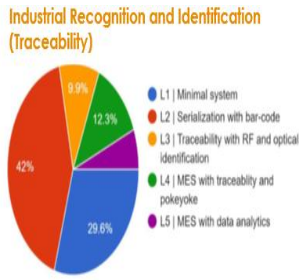


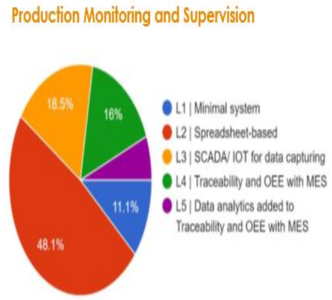


2. Do Stage

All incoming and outgoing goods control, inspection have been standardized using standard forms for manual capturing of data or standard templates in some home-grown tools. Production monitoring and supervision are still xls based. However Indian automotive OEMs are in initial stages of adopting Manufacturing Execution System (MES).



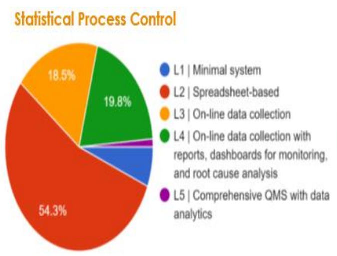


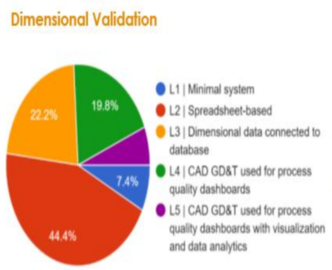


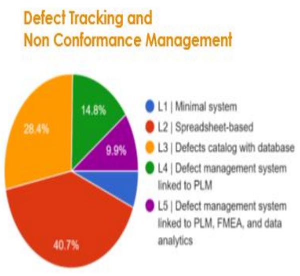
III. CHECK STAGE

OEM do measure the Statistical deviation of supplier quality through SPC charts but all those is more manual and once the component/sub-system/system is already in OEM's premises. Defect are tracked pre-installation on the assembly line but most of them are detected much later in the development cycle resulting in warranty cost and damage of brand image.

Defect tracking is done by a proper tracing it to change management (engineering or manufacturing) is not in place for majority of the OEM and Tier-1's.

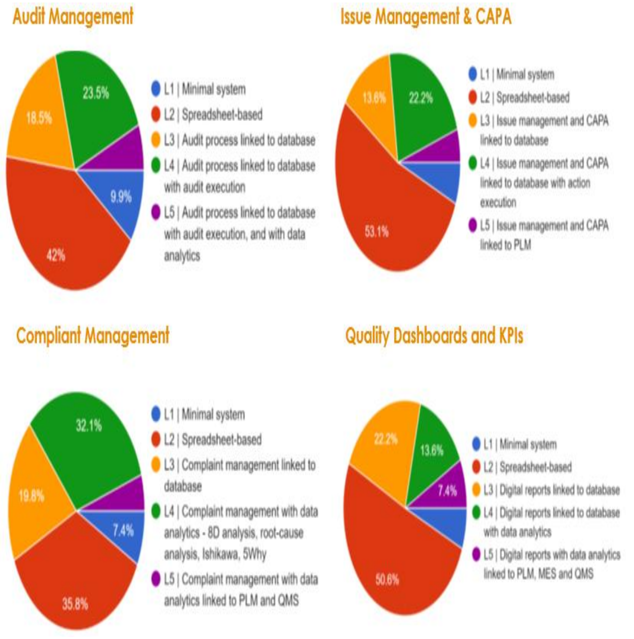






3. ACT STAGE

A more continuous improvement stage is in place but more than 40% of audit results or Issue in form of field failure or line failure is not report in real time to design or production department for corrective and preventive action. This make the organization more of problem fixing mode rather than problem solving mode. Resulting in more cost of the product.



1.7. LNS Research – Confirmation of survey

The above survey at the CII events in three cities matches with the LNS Research Quality Management Survey which was completed by over 700 executives and other senior leaders coming from a variety of company sizes and geographies across a range of industries.

The research report the Top Operational Challenges perceived from the interviewed.Almost 40% of the interviewed top managers identify ineffective quality management as originated from:

- Disparate quality systems and data sources 38% -> due to chronic underinvestment in quality, any department develops its own custom systems, no standard processes among different custom systems
- Quality metrics not effectively measured 34% -> due to lack of technology and lack of formal processes
- Quality is considered to be a department, not a global responsibility 33% -> Quality is not managed as a global responsibility
- No formal process for managing risk 23%
- No formal process for continuous improvement 23%
- Lack of visibility into supplier quality 21%
- No formal process for capturing non-conformances 16%
- Audit and compliance management is ad-hoc 15%
- Engineering lacks feedback on quality 15%
- Lack of executive support 13%

1.8. Cost of Quality

However, here are the suggested steps if we must find the potential impact our solutions can have on Cost of Quality:

- **Step 1**: Get customer data on what is their cost of quality or at least what is the cost of poor quality.
- **Step 2**: Get customer data on the contributors to the cost of poor quality (Root Causes).
- **Step 3**: Technical team should validate whether we have a solution that could help alleviate the root causes.
- **Step 4**: Based on Steps 1-3, arrive at the potential impact SISW can potentially have.

To help on Steps 1 and 2, here are few guiding questions which was made by the team:

Reduce Cost of Quality or Cost of Poor Quality (Cost Impact)

Quantitative:

1. What is the revenue from Sales?
2. What is the current cost of quality as % of Sales or (absolute value in INR)?
3. If cost of quality not measured, then what is the cost of 'poor quality' as % of Sales or (absolute value in INR)?
4. Break-up of 'cost of poor quality'- Pareto as % of Sales (absolute value in INR)?
5. How much is rejection as % of Sales (or absolute value in INR)?
6. How much is rework as % of Sales (or absolute value in INR)?
7. Opportunity loss- Production loss, delays due to line stoppages due to quality issues (or absolute value in INR)?
8. What is Overtime cost for correcting any quality issue (or absolute value in INR)?
9. How much is external failure cost - warranty (or absolute value in INR)?
10. How much is external failure cost – repairs and servicing (or absolute value in INR)?
11. How much is external failure cost – recalls or service campaigns (or absolute value in INR)?
12. How time is spent on failure analysis per annum (total hours) (absolute value in INR)?
13. How many customer complaints are processed per annum? Cost of attending to customer complaints?
14. How much time is spent on quality planning per annum (total hours)?
15. How much time is spent on quality assurance activities per annum (total hours)?
16. Time spent on inspection?
17. Time spent in supplier audits?
18. Time spent in supplier ratings?
19. Any other major Cost of Quality driver? Its value as % of Sales?

Qualitative (MUST):

20. What are the top ROOT CAUSES for rejection (contributing at least 80% of the total rejection cost head)?
21. What are the top ROOT CAUSES for rework (contributing at least 80% of the total rework cost head)?

22. What are the top ROOT CAUSES for Warranty cost (contributing at least 80% of the total Warranty cost head)?
23. What are the ROOT CAUSES for recall, repairs or service campaigns?
24. What are the ROOT CAUSES for any delays in production due to quality (if any)?
25. Key Supplier related issues?
26. Key production related issues?
27. Key design related issues?
28. Where is the gap in closed-loop quality process as on today?

The information received by two of the companies – on e two-wheeler and other passenger vehicle manufacturer cannot be published here but these above insightful question gave us a deep understanding of how is quality is incorporated, view, measured and tools implemented in these organization.

1.9. Conclusion of the Two Surveys

Quality Processes can be effectively explained with PDCA (or Deming cycle) cycle described in 4 phases PLAN-DO-CHECK-ACT, the basis for all quality management systems, to manage the continuous improvement process.

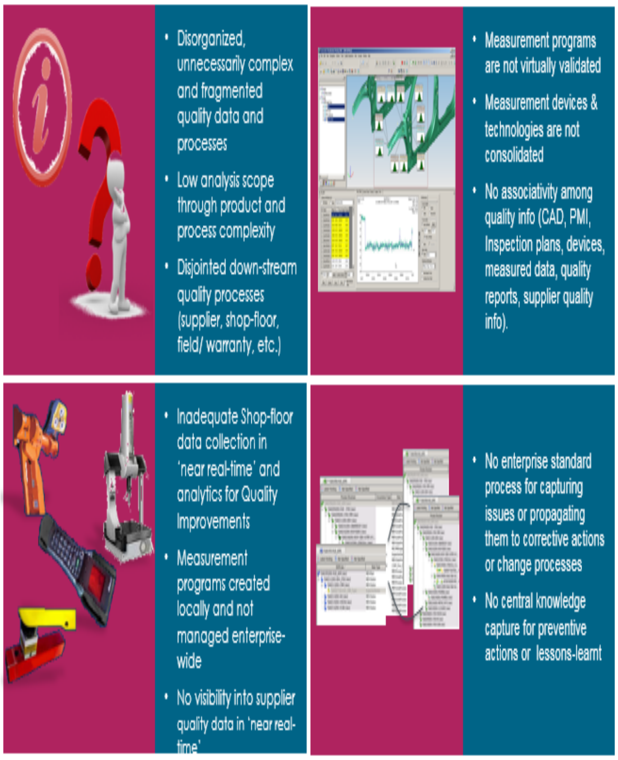
- The first survey – Quality Maturity assessment has proved still the organizations does not have an online, closed loop integrated solution.
- The second part is workshop at selected organization to show the holistic big picture of closed loop quality. The data collected in OEMs in relation to defects, issues and others are lot passed on in real time or proper manner back to design or production for resolving the root cause of the issue.

To close the quality loop is very important to manage the lessons learned process, e.g. to get information from the field (customer complaints), perform analysis on the information and to report the feedback automatically into the FMEA. Goal is to optimize the APQP process, to produce products with zero defects.

2. Solution – Closed Loop Quality on Collaboration Framework

2.1. Summarizing the Issues in Different Stages of PDCA

If we put the above section 2 survey in the Deming cycle of Plan-Do-Check-Act, it can be summed as below:



2.2. QMS Solution

The solution to the same will be an online connected system to address the various activities done in PDCA (Plan, Do, Check and Act).The plan-do-check-act (PDCA) cycle describes the phases of the continuous improvement process (CIP) and should form the basis of all quality management systems.

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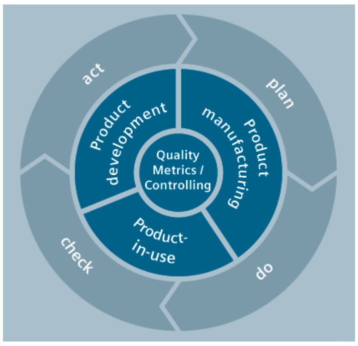
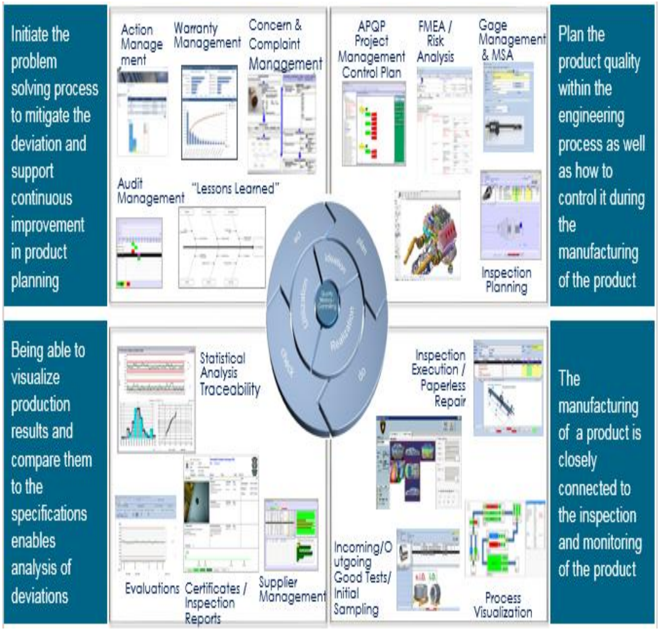


Advanced product quality planning (APQP)

- Control plan (process flowchart)
- Audit management
- Failure mode and effects analysis (FMEA)
- Inspection plan management (IPM) including graphical options
- Concern and complaint management (CCM)
- Statistical process control (SPC) in-process inspection
- Warranty management
- Traceability management
- Incoming goods/outgoing goods inspection
- Integrated workflow management



Plan involves analyzing the status, developing improvement potentials and the compiling conceptual realization. The organizations should Plan the product quality within the engineeringprocess as well as how to control it during the manufacturing of the product. The following functionalities should be part of the digital online QMS system for the Plan stage:

- Deliverable based Project Management/Program Management
- Control Plan/Flowcharter
- FMEA/Risk Analysis
- Inspection equipment/Qualification
- Detailed Production Planning
- Inspection Planning

Do embodies the practical realization of the concept, which is tested on a small scale using simple means and test equipment. The manufacturing of a product is closely connected to the inspection and monitoring of the product. The following functionalities should be part of the digital online QMS system for the Do stage:

- Machine data acquisition (MDA),
- Electronic Work Instruction
- Production-Assembly-Laboratory Inspections
- Incoming/Outgoing good tests
- First Sample Inspection
- Machine Visualization

Check generates, and checks results of the test run and sets the standard. An organization should be able to visualize production results and compare them to the specifications (minimizesanalysis deviations. The following functionalities should be part of the digital online QMS system for the Check stage:

- Production controlling
- Process Monitoring (SPC Charts)
- Evaluations
- Certificates/Inspection reports
- Supplier Management

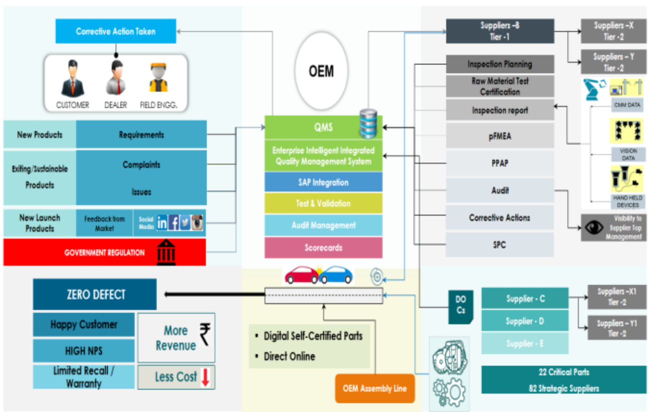
Act, the last phase, involves wide-scale implementation of the new standard andregular monitoring through audits.Initiate the problem-solving process to mitigatethe deviation and support continuous improvement in product planning. The following functionalities should be part of the digital online QMS system for the Check stage:

- Action Management
- Warranty Management
- Concern and Complaint Management
- Audit management
- Lessons Learn

2.3. Proposed ei2QMS Framework (Enterprise Integrated Intelligent Quality Management Solution)

A centralized enterprise integrated intelligent quality management solution is depicted below:

Part – 1: A centralized database to capture the voice of customers and dealers, any filed failures from the field engineer, service centers, customer complaints, feedback from social media like company Facebook page, twitter, Instagram and professional site like LinkedIn. This is depicted in the left side of the diagram.



Proposed ei2QMS Framework (Enterprise Integrated Intelligent Quality Management Solution)

Part – 2: In today's every changing world, the OEMs (Indian automotive OEMs are no exceptional) have a focus on design, innovation and marketing while rest of the work has been outsourced to Tier-1 suppliers.

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This growing supplier complexity, increased government regulations and ever-more demanding customers are exerting intense pressure on the automotive industry's quality management systems. This has lead manufactures to pursue a more strategic approach towards quality.

Importance of supplier quality - Customer research firm recently published some of the recall impacts because of supplier quality – 1 million USDfor a Safety Catch, 14.57 million USDfor Ignition Switches failure, 14 million USD for failure of Cruise Control Switches.

Today, the suppliers do send the entire PPAP documents like FMEA sheets, FSI/FAI to OEM along with the components/sub-system/system. All components are certified. But what the current framework puts in place is the proactive measure. As depicted in the right part of the diagram, a tool is installed at the supplier end, an upper & lower limit of the specification is defined by the OEM, a SPC (Statistical Process Chart) is generated. Any deviation is caught at the supplier end. The result is made available online and real time to both the supplier management and the OEM. Thus, any bad part is stopped right at the supplier end. The correct lot which comes to the OEM is digitally self-certified part and is put direct on production line.

Part 3- The entire solution is integrated with other enterprise application like ERP (SAP/Oracle, …), PLM (Teamcenter/ENOVIA/Windchill)

Part 4– These summarizes how through a holistic view of the product & process quality; in house and supplier quality; continuous feedback from customers, dealers, field & service engineers, integrated enterprise applications like ERP & PLM, an organization can plan for a Zero Defect vision through happy customer and high NPS (Net Promoter Score) which results in more revenue for the customer and also limited recall/ warranty which means less cost to the organization.

IV. CONCLUSION:

In the current era of Smart Manufacturing, Industry 4.0, Quality 4.0 also the correct way to view a holistic quality management system is through the lens of operational excellence - people, process and enabling technology. These three elements are interconnected and have an impact on each other. To achieve the maximum impact of investment of product and process quality, leaders must optimize across all the three elements. The crux to achieve a world class quality through closed loop quality management system is to have a quality management system based on proper technologies, incorporating recognized industry standard and built & leveraged by skilled people at the organization.

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