

Inspection Methods during Automotive Assembly in 21st Century

Utkarsh Kulkarni

*School of Management- PG under Faculty of Management
MIT World Peace University, Kothrud, Pune, Maharashtra, India*

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ABSTRACT: With growing global competition, quality management is becoming increasingly important to the leadership and management of automotive industry. This paper gives a brief idea on how to inspect different process parameters to enhance and maintain quality in an Automobile industry. The study will tell how to view different parameters from quality point of view and will guide in determining and maintaining these parameters for effective and efficient running of the industry with the help of different formats for various departments.

Keywords: Inspection, Automotive Assembly, Inspection Formats, Process Parameters for Assembly Shops, Quality Control, Quality management

I. INTRODUCTION

Quality Management engages all divisions, departments and levels of the organization. TQM companies are focused on the systematic management of data in all processes and practices to eliminate waste and pursue continuous improvement. The goal is to deliver the highest value for the customer at the lowest cost while achieving sustained profit and economic stability for the company. While every organization should implement its own specialized form of quality management, there are some basic core principles that guide every quality effort. The single most important element of quality management is the focus on the customer. All types of automotive industries have reduced costs, increased process efficiency and improved the quality of their products and services by working to meet the needs of the people they serve through the application of total quality management (TQM) concepts and tools.

II. OBJECTIVE

To learn different process parameters which are to be considered for Quality Control purpose. Also to

make formats for the parameters which are to be checked on daily routine basis.

III. SCOPE

Pathways are developed for Automobile industries in terms of formats for different process parameters. The study seeks to find out facts and opinions of quality enhancement and quality control.

IV. LITERATURE REVIEW

Producing with “quality” is the philosophy of any company in Automobile industry. The literature is based on the designing of the business process of production with a view of minimizing the chances of producing substandard goods. Quality control is a conventional way that businesses have used to manage quality. Quality control is concerned with checking and reviewing work that has been done. This is mainly done by inspection of products and services that take place during and at the end of operation process.

In the article ‘QUALITY MANAGEMENT IN THE AUTOMOTIVE INDUSTRY’ GOICOECHEA, I. & FENOLLERA, M. says that: An established methodology is followed from product development through production. The investigation is to set up a relationship between the different stages of the Product Realization Process (PRP) and the most suitable quality tools for each of them, so that it can be a support to the organizations interested when it comes to choosing the most effective tools depending on the quality strategy they adopt.

In the article ‘Manufacturing enhancement in car body shop line’ C.S. Sundar Ganesh and C. Praveen Kumar says Productivity is the average measure of the efficiency of the production. It can be expressed as the ratio of outputs to inputs used in the production process, i.e. output per unit of input. It is the major criteria in any manufacturing industry; hence every manufacturing industry wants to increase their productivity by all means.

According to Deming (1986), ‘inspection with the aim of finding bad product and throwing them out is too late, ineffective and costly’. Quality to him comes from the improvement in the process rather than inspection.

V. STATEMENT OF PROBLEM

In an Automobile industry there are many aspects which are to be overlooked thus to study different process parameters which can affect quality related problems and can cause discursion in the process becomes important. Daily routine check list formats can avoid uncertain damages in

terms of time, money, quality of product or customer’s satisfaction level, thus to study working procedures for smooth running of operations.

VI. ANALYSIS OF FINDINGS

VII. Considering following generalized flow chart of an Automobile industry for studying,

- i) Different parameters which are to be considered from Total Quality Management point of view.
- ii) Remedies for each parameter for obtaining quality output.

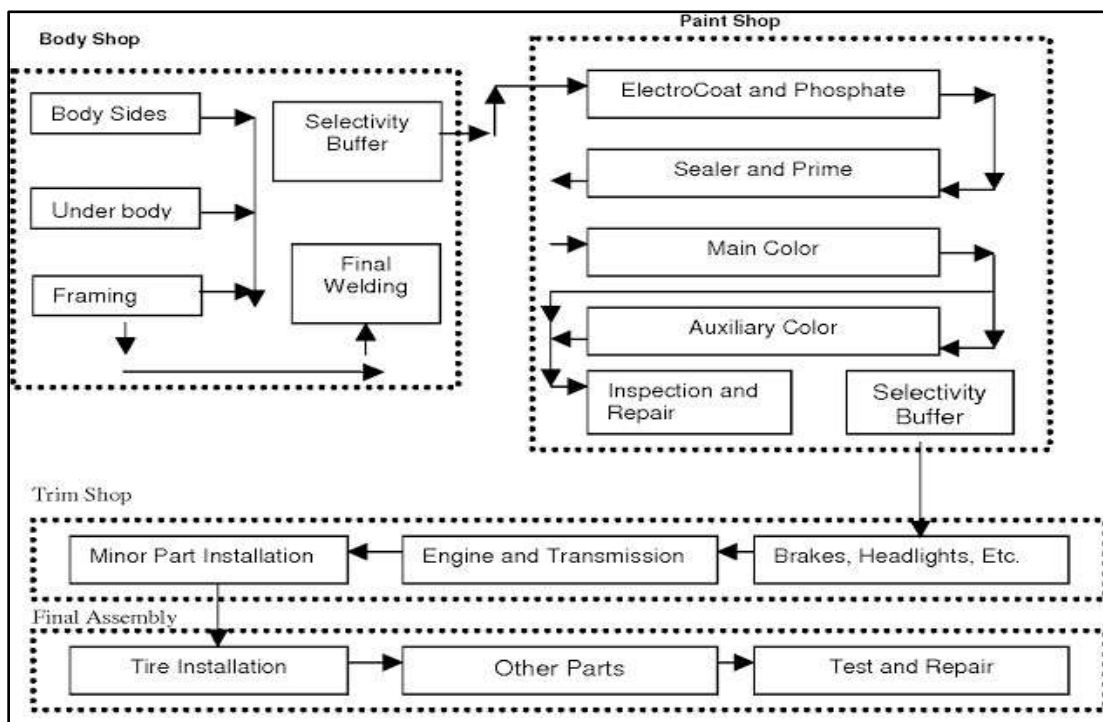


Fig 01: Generalized flow chart of an Automobile Industry

• **PRESS SHOP** – The foremost process in an automobile industry starts from press shop. In this shop computer controlled line converts sheet metal to body panels of high dimensional accuracy and consistency. Important components of press shop are the hydraulics, as well as the lubrication and compressed air supply to the presses and grippers.

i) Parameters to be checked :

- a) Access restrictions to coil transfer station
- b) Coil storage trolley
- c) Strip flow
- d) Unwinding of coil
- e) Strip washing plant
- f) Lubrication unit
- g) Loop pit

- h) Stress on Straightener rollers
- i) Position control of load carriers
- j) Part detection on conveyor belt
- k) Position of the positioning carriage
- l) Vacuum required for suction grippers
- m) Lubrication
- n) Press shop operators knowledge
- o) Die setting and its performance
- p) Time required for die setting
- q) Periodically checking of die clamp, press stroke, braking system etc
- r) Marking and measuring tools
- s) Selection of die
- t) Operators safety

ii) Remedies :

- a) For operator's protection, safety lights or visual sign are to be installed to restrict unauthorised access to the coil transfer station.
 - b) Capacity sensors should be installed in the coil storage trolley for level detection.
 - c) Strip flow in blank cutting plant and coil unwinder should be monitor with the help of O1D PMD sensors.
 - d) Unwinding of the coil should be done with the help of pressure sensors which will monitor the system pressure resulting in smooth running of the machine
 - e) While washing the steel strip SI series flow monitor detects the flow of the special oil thus this should be followed for properly washing the strip using high viscosity oil.
 - f) Inductive full metal sensors should be used for eccentricity monitoring.
 - g) Sag control with PMD time of flight sensors should be used for continuously measuring the sag of the coil loop.
 - h) Analogue pressure sensors are to be installed for controlling the straightening rollers. The strip runs through these multiple straightening rollers to eliminate the bending stress.
 - i) Category 4 and SIL 3 fail-safe inductive sensors are required to directly detect the safe position of load carriers without contact and without requiring a special counter piece.
 - j) For detecting weather a blank is placed on the conveyor belt or not, there are R series full metal inductive sensors available which are designed for heavy duty work which is conducted in a press shop.
 - k) The rectangular design IDC inductive sensors can be installed for detecting the position of the positioning carriage. In this way the position of the positioning carriage can be determined for automatic locking.
 - l) In a press shop it is essential to have a vacuum monitoring sensor which will detect the required vacuum for operating the suction grippers. It is suggested to use PN7 series vacuum sensors for this purpose.
 - m) Lubrication is one the important parameter to be considered. Pressure sensors in the circulating oil lubrication will always give correct pressure value to the service personnel.
 - n) Supervisors should ensure that the press shop operators and helpers have fully understood the job which is to be done so as to decrease the chances of rework or scrap. Operators should select the right drawings and sketches to enable them to join the required parts as mention the manual.
 - o) Operators should check the die setting before each pressing process sequence and at the end of each pressing sequence so that any change in die performance can be immediately detected and suitable action can be taken.
 - p) If setting of die and changing the die is taking too much time than a die setting kit is to be presented at the shop floor during press operations.
 - q) Ensure availability of various types of marking and measuring tools required during the operations and also the tools should be calibrated.
 - r) Ensure that the operator and helper are using the required personal protective equipment like gloves, ear plugs, safety shields, masks, helmet, safety shoes etc at the time of conducting the pressing operation.
 - s) In additional the operators should select the correct die as required by the process and that the die setting parameters are selected as mentioned in the work instruction. They should also regularly clean the machine parts and lubricate them. The operator himself should be able to determine flaws such as surface cracks, chipped edges etc
 - t) At last a proper observation and analysis is to be done on any irregularity in the pressing process and preventive steps should be taken accordingly so that the overall quality of the output is as per the desired standards.
- **BODY SHOP** – A hi-tech line that builds full body shells from panels. Automated robotic arms are used for intricate welding operations that ensure superior and consistent build quality. In body shop, up to 200 individual parts and assemblies are put together to form a self supporting body. The requirements for the reliability and availability of the plant are very high in body shop, since the material flow must not stall in the subsequent painting process.
- i) Parameters to be checked :**
- a) Hanger holding position of the Robot
 - b) Tool dresser
 - c) Clamp and jig arrangements
 - d) Cooling water and industrial gases
 - e) Turntables
 - f) Handling
 - g) Gripping/clamping
 - h) Gluing/sealing
 - i) Manipulators
 - j) Body cleaning
 - k) Body storage area

l) Body position during welding process

ii) Remedies :

- a) Hanger holding position of the robot is to be checked and modified if necessary for avoiding the interlocking problem.
- b) Automatic tool dresser is suggested for using in spot welding process to change pneumatic gun with servo gun.
- c) Flow sensors are to be used for monitoring cooling water in welding guns, measuring compressed air consumption and for monitoring shielding gas. Also pressure sensor should be used for monitoring pressure on welding guns.
- d) The various parameters related to the turntables can be monitored by photoelectric sensors for checking the load, inductive sensors for checking parts and safe position of the body and vision sensors for part detection.
- e) In handling operation pressure sensor are to be used for detecting vacuum on suction grippers and laser sensors or distance measurement sensors are to be used for 'empty' detection on material carriers.
- f) Considering the clamping operation inductive sensors are to be used for locking check on the clamps and splitter boxes for signal transmission.
- g) For sealing purposes temperature sensors should be used for monitoring temperature of mixing head and that of nozzles. Pressure sensors will also help to monitor pressure of adhesive.
- h) Manipulators related quality control actions would be to add pressure sensors for monitoring pressure of pneumatics, AS-interface air boxes for checking valve connection and cylinder as well as flow sensors to make sure proper monitoring and working of the manipulators.
- i) While body cleaning pressure sensors would help to measure pressure on pumps, flow sensors will monitor the flow and inductive sensors will detect the proper positioning of the body as proper cleaning will avoid various defects which can cause great losses to the company.
- j) In body storage area, condition monitoring of drives is important for that vibration monitoring systems are available, cable monitoring on lifts can be done by fail safe inductive sensors and for identifying the bodies 1D/2D code readers can be used.
- k) Right body position during the welding process is very important and it can be monitored by

photoelectric sensors which detect the position of the body on the skid.

- **Paint Shop** – It is a process in which the car body which comes from the body shop is passed through a series of dip tanks designed to stop corrosion and further cleans and paints the body for decoration purposes as well as for protecting the body from the UV light. A paint shop incorporates conveyor technology, various dip tanks as well as numerous robots for applying the individual paintwork. In between there are evaporation zones and drying chambers. Heat generation, water treatment, paint tank maintenance, exhaust air and fresh air supply are absolutely vital for reliable operation.

i) Parameters to be checked :

- a) Pre-treatment
- b) Cathodic e-coating
- c) Water treatment
- d) Fresh air/ exhaust air
- e) Paint recycling
- f) Painting robots
- g) Heat generation and distribution
- h) Cleaning agent
- i) Bath maintenance
- j) Paint supply
- k) Fan Monitoring
- l) Identity of add-on parts

ii) Remedies :

- a) During pre-treatment process, use of pressure sensors, flow sensors, level sensors and inductive sensors are essential for properly monitoring the pump pressure, freshwater inflow, and limit level detection and for position detection.
- b) It is important to measure temperature as well as pressure during the coating process, use of temperature and pressure sensors should be made.
- c) During the water treatment proper positioning of the car body is to be checked for proper processing and one should also monitor the flow of water.
- d) Pulse evaluation systems should be installed for speed measurement of fresh air and exhaust air, also use of vibration monitoring system is suggested.
- e) Optical detection of painting robot should be monitored by using laser sensors or distance measurement sensors. Proper maintenance and up gradation of the robotic systems is essential

to maintain the quality work and smooth running of the paint shop.

- f) Heat generation and distribution system requires fail-safe inductive sensors to monitor high speed doors whereas photoelectric sensors for general applications such as checking the fan etc.
- g) A special cleaning solution for degreasing is required for an optimum washing process thus monitoring the fill level of cleaning agent is crucial which can be done by using level sensors with an analogue output.
- h) A proportion of the paint is continuously removed from the dip-bath and fed through the ultra filtration unit. The residual solid content is mixed back into the bath. Here the temperature sensors monitor the correct temperature.
- i) Pump monitoring is essential for paint supply. The vibration sensor monitors the function of the pump motor.
- j) The spray booths are maintained at a slight positive pressure to keep impurities from the air at bay. If the fan breaks down, quality problems results. The photoelectric sensor scans the fan belt for breakages.
- k) Identifying appropriate add-on parts is an important parameter for the systems. The painted add-on parts must be assigned to the corresponding body. The multi code reader detects the codes on the build tickets. This prevents incorrect assembly of add-on parts.

- **TRIM SHOP** – In this shop, the combination of engine and gearbox also called as powertrain forms the heart of the drive unit. The basic components such as crankcase, cylinder head or gear box housing are made in the foundry. These components are then finished by mechanical processing. In many work steps, gear wheels and shafts are processed and then assembled into gearboxes. In engine production, powerful petrol, diesel or hybrid drives are created out of the mosaic of crankshaft, camshafts, connecting rods and many other parts and sub assemblies.

i) Parameters to be checked :

- a) Foundry coolant
- b) Casting moulds
- c) Chip removal machine
- d) Part seat of work pieces
- e) Internal cooling of drill
- f) Hydraulic aggregates
- g) Filter
- h) Camshaft manufacturing
- i) Lubricant leakages
- j) Leak test

- k) Driveshaft manufacturing
- l) Gearbox assembly
- m) Shipping of engine and transmission to assembly line

ii) Remedies :

- a) Melt furnaces and casting must be cooled. Water is drawn from deep wells for this purpose. A volumetric sensor detects whether air is sucked up with it, thus helping to avoid damage to the equipment.
- b) The casting moulds are united automatically. Use of photoelectric sensor will help to detect the casting moulds for the control system.
- c) Chip removal machine blows out drill holes. For this compressed air meters detect a defined air volume for blowing purpose and pressure sensor monitors the required minimum pressure.
- d) The workpieces to be processed must lie flat on the workpiece carrier to ensure dimensional accuracy. A control unit for part seat monitoring is suggested.
- e) Continuous cooling of the drill is essential if not much coolant is being used or if the drill holes are long. The mechatronic flow sensor is able to detect extremely quickly if the amount of coolant is no longer sufficient.
- f) Monitoring of power packs is essential and must be taken care of by using temperature sensors and level sensors with guided wave radar in the hydraulic units.
- g) For monitoring the filters, electronic pressure sensors with an analogue input evaluate the pressure difference in filter elements in combination with PA type transmitters should be used.
- h) In camshaft manufacturing, while grinding the surface quality produced is extremely important for the quality of the shafts. To ensure the quality, the grinding emulsion must be applied constantly. To ensure the traceability, the camshafts should be coded with data such as production date and batch information etc.
- i) An alarm system should be installed which will trigger an alarm when there is any lubricant leakages in pipes and tanks.
- j) Leak test on the components and assemblies is another parameter where we have to test pieces under pressure using compressed air. So using appropriate pressure sensors is necessary.
- k) In the manufacturing of drive shafts, the object detection sensor will check whether a needle bearing has been assembled or not and whether it is the correct bearing.

- l) In gearbox assembly shop, thanks to RFID technology, the current work step of the gearbox is always known.
- m) Engine and gearbox variants differ from each other in many ways for country specific versions. Before shipping to the assembly plant, the presence of, for example, stoppers, ID marks and similar are to be checked and this can be done accurately, conveniently and with least amount of time with the help of vision sensors for checking the tasks.
- **ASSEMBLY SHOP** – Piece by piece, the complete vehicle is formed from many individual components. Countless bolts fix the assemblies in their places. Clips hold carpets and the interior trim in place. Kilometers of cables and wiring form the vehicle's nervous system. The tyres and wheel rims are often used to further individualize the wheels. Customer-specific equipment options make the car more interesting but represent huge logistical challenges. Here it is absolutely essential to assign the parts and components according to the equipment options desired by the customer. In the end, it is the assembly which determines the success of the transformation of jigsaw pieces into high-quality product.
- i) Parameters to be checked :**
- a) Function check for electrical equipment
 - b) Dashboard installation
 - c) Assembly of door module
 - d) Windscreen assembly
 - e) Chassis assembly
 - f) Quality assurance in the suspension assembly
 - g) Wheel assembly
 - h) Filling of various fluids
 - i) Marriage
 - j) Rain test
 - k) Function test
- ii) Remedies :**
- a) After the assembly of mirrors, locks and window lifts, the electrical function should be checked using a diagnostics connector device. It will detect whether the device is still connected after the test and release the next production step.
 - b) Proper positioning of the instrumental panels such as dashboard is important, for that O2V object detection sensors are available which will help to detect the position during the approach, and give correction data to the robot control if necessary.
 - c) While assembling the doors to avoid some mistakes proper identification on the doors should be given so that right doors can be assemble on the right car body. 'Compartment occupied' detection sensors are also suggested for proper working condition.
 - d) While assembling the windscreens we have to make sure that there are proper grippers in use. Doors should be protected to avoid some damages. Photoelectric fork sensors/ angle sensors are essential for assuring the right quality work in this process.
 - e) For chassis assembly the quality assurance can be taken care by vision sensors and some inductive as well as capacitive sensors if necessary.
 - f) While assembling the suspension one should monitor the exact position of the brake discs and there should be a sensor which will detect the right position and then only allow proceeding further. This saves subsequent costs, which used to be incurred due to the rectification work required for incorrectly assembled brake discs.
 - g) Again in wheel assembly the O2V sensors can help to detect pre-programmed bolt hole patterns in the wheel rims. The robots can grip the wheels in a defined way and approach the bolting position with extreme precision.
 - h) Before the function test, the car needs to be filled up with various fluids such as windscreen washer, brake fluid and a minimum amount of fuel. The level sensor can be placed here to detect the preselected amounts on extraction from the appropriate filling station.
 - i) One of the important steps in assembly shop is uniting the body with the drive train. Here many precautions are to be taken. Proper control of movement of car body is to be taken care of.
 - j) In rain test the finished vehicles are tested for leaks and for this purpose proper flow of water with right pressure are essential and these can be monitored by placing a flow and pressure sensors.
 - k) For checking the vehicle properties the roller dynamometer can be used for testing, for example, acceleration and deceleration. Adhering to tailpipe emission values is also an important test criterion. The exhaust gases must be extracted under controlled conditions.
- **Constraints :**
- a) Time - If a company is looking for high quality output, than its policy management team and daily management team should give a specific amount of time in studying the various factors affecting quality and find solutions for the same.

b) Cost - For achieving high quality product with zero defects the company has to make initial investment for installing various sensors, conducting training programmes and audits etc and has to make an effort in proper maintenance of machine and equipments.

• **Advantages :**

a) No stoppages

- b) Risk of occurring any defect will be minimum
- c) Reduced inspection cost
- d) Lead time will be reduced
- e) Smooth and continuous operation is possible.
- f) High quality outcomes are achieved.
- g) Reduced rework cost and scrap
- h) Productivity improvement
- i) Higher customer satisfaction

VI.II. Routine Quality Inspection Formats:

D) Press Shop

Sr. no.	Check Points	Date- / /		Suggested Timings	Remarks
		1 st Shift (✓/✗)	2 nd Shift (✓/✗)		
1)	Strip flow			7.15 am, 3.15 pm	
2)	Unwinding of coil			7.30 am, 3.30 pm	
3)	Strip washing plant			7.45 am, 3.45 pm	
4)	Lubrication unit			7 am, 3 pm	
5)	Loop pit			8 am, 4 pm	
6)	Stress on Straightener rollers			9 am, 5 pm	
7)	Position control of load carriers			8.15 am, 4.15 pm	
8)	Part detection on conveyor belt			7.30 am, 3.30 pm	
9)	Position of the positioning carriage			7 am, 3 pm	
10)	Vacuum required for suction grippers			7 am, 3 pm	
11)	Die setting and its performance			7 am, 3 pm	
12)	checking of die clamp, press stroke, braking system			7 am, 3 pm	
13)	Marking and measuring tools			10 am, 6 pm	

Checked By:

Date:

Sign:

Quality Incharge:

Date:

Sign:

Verified By:

Date:

Sign:

II) Body Shop

Sr. no.	Check Points	Date- / /		Suggested Timings	Remarks
		1 st Shift (✓/✗)	2 nd Shift (✓/✗)		
1)	Hanger holding position of the Robot			7 am, 3 pm	
2)	Tool dresser			7.15 am, 3.15 pm	
3)	Cooling water and industrial gases			7 am, 3 pm	
4)	Turntables			7.30 am, 3.30 pm	
5)	Gripping/clamping			7 am, 3 pm	
6)	Gluing/sealing			8 am, 4 pm	
7)	Manipulators			7.15 am, 3.15 pm	
8)	Body cleaning			7.30 am, 3.30 pm	
9)	Body storage area			8.30 am, 4.30 pm	
10)	Body position during welding process			7.15 am, 3.15 pm	

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III) Paint Shop

Sr. no.	Check Points	Date- / /		Suggested Timings	Remarks
		1 st Shift (✓/✗)	2 nd Shift (✓/✗)		
1)	Pre-treatment			7 am, 3 pm	
2)	Cathodic e-coating			7.15 am, 3.15 pm	
3)	Water treatment			7 am, 3 pm	
4)	Painting robots			7 am, 3 pm	
5)	Heat generation and distribution			7.30 am, 3.30 pm	
6)	Cleaning agent			7 am, 3 pm	
7)	Paint supply			7.15 am, 3.15 pm	
8)	Fan Monitoring			7 am, 3 pm	

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IV) Trim Shop

Sr. no.	Check Points	Date- / /		Suggested Timings	Remarks
		1 st Shift (✓/✗)	2 nd Shift (✓/✗)		
1)	Foundry coolant			7 am, 3 pm	
2)	Casting moulds			7 am, 3 pm	
3)	Chip removal machine			7.15 am, 3.15 pm	
4)	Internal cooling of drill			7.15 am, 3.15 pm	
5)	Hydraulic aggregates			7 am, 3 pm	
6)	Camshaft manufacturing			8.15 am, 4.15 pm	
7)	Lubricant leakages			8 am, 4 pm	
8)	Driveshaft manufacturing			8.30 am, 4.30 pm	
9)	Gearbox assembly			8.45 am, 4.45 pm	
10)	Part seat of work pieces			7.45 am, 3.45 pm	

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Verified By:
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V) Assembly Shop

Sr. no.	Check Points	Date- / /		Suggested Timings	Remarks
		1 st Shift (✓/✗)	2 nd Shift (✓/✗)		
1)	Function check for electrical equipment			7 am, 3 pm	
2)	Dashboard installation			7.15 am, 3.15 pm	
3)	Assembly of door module			7.30 am, 3.30 pm	
4)	Windscreen assembly			7.45 am, 3.45 pm	
5)	Chassis assembly			8 am, 4 pm	
6)	suspension assembly			8.15 am, 4.15 pm	
7)	Wheel assembly			8.30 am, 4.30 pm	
8)	Filling of various fluids			9 am, 5 pm	
9)	Marriage			7 am, 3 pm	
10)	Rain and function test			9.30 am, 5.30 pm	

Checked By:
Date:
Sign:

Quality Incharge:
Date:
Sign:

Verified By:
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Reflection on Formats:

These are the sample formats which can be used in any Automobile industry for quality control purpose. There are many parameters as mentioned in tables, which are to be checked on routine basis for smooth running of the process as well as for quality assurance. Now the different parameters can be checked by either the machine operator, Supervisor or by the Quality In-charge persons who are hired by the quality department depending upon the importance of the parameter

and its consequences if anything going wrong can make huge loss in terms of cost, time and quality.

As shown in tables, we can see that timings of checking the parameters are suggested and mentioned while considering the sequence of the processes as well as some are meant to be checked before starting the process to ensure the quality and to avoid damages and wastage of resources. Timings for both the shift are mentioned as the parameters needs to be checked in both the working shifts i.e. 1st shift and 2nd shift, just to be on the safer side. Timings may vary from

companies to companies depending upon their schedules, convenience and accuracies.

There is also a 'Remark' column which is to be used whenever a problem has occurred in any of the given parameters, which further will guide and direct the superiors to take the required decision and action on it. In case everything is in perfect working condition than 'Ok' should be mentioned in the remark column.

At last the format include details of the person who has checked the parameters, department in which the person is related to and the person who has verified the report once it has handover to the person who is concerned, which will help to keep a proper record and may help the maintenance department to a particular extent.

CONCLUSION:

The objective of this research was to study about the approaches required for continuous improvement in assembly line of an Automotive Industry. Thus we have found out the different process parameters which are to be maintained and inspected for smooth operation of an Automobile industry and had developed daily routine basis check list formats for same.

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