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Implementation of Total Productive Maintenance in Automotive Chain Manufacturing Industry: A Case Study

G. D. Shelke[1], M. Javed[2], S.D. Walde[3]

[1, 2, 3]MSS College of Engineering & Technology, Nagewadi, Jalna Maharashtra, India

Abstract: ***Total Productive Maintenance is shared and Implemented in Automotive Chain Manufacturing Industry. The Research investigates the answers of these Challenges by analyzing and modeling the equipment condition and response of action required in Chain Manufacturing Industries. Overall Equipment Efficiency, Production per hour, Output/Man, Reduction of Breakdown hours & Occurrences., Reduction of Customer Complaints, Reduction of In-house rejection. Reduction of Accidents is used as measures of Success of TPM Implementation. The Losses related with the equipment efficiency, Customer Complaint Data from Customer Portal, Production/ hours, Output/man\ data & Accidents data Collected from various sections & division, That data we called as " BENCH MARK Data to Identified the success of implementation in the Company. The Method of this Problem to Implement the five Pillar of TPM Aimed at Strengthening of process in more Realistic application. For effective utilization of TPM 1st developed the TPM Policy and its is linkage with the Key Performance indicators, key Area of inductor & Key Management index.***

Keywords: OEE, Total Productive Maintenance, 1s-2s, Production per hours

1. Introduction

Ensuring earning of targeted profits in manufacturing is becoming tough day by day Market conditions do not allow revise/increase price of products due to tough competition, where as ask for price reduction. On Other hand, Power cost going up Overheads going up Hence, profits are shrinking. Project investigates the Optimum utilization of resources 4M1T Resources i.e. Man, Machines Material, Method & Tooling. Optimum Utilization of resources is the main objective of TPM it insure the effective implementation of Total Productive Maintenance. It include total Employee involvement to achieve the desired objective this Projects. Due shrinkage in Profit TPM is the Tool in which Optimum Utilization of resources is Possible to achieve the project objectives. TPM as a tool helps to: Elimination of production losses increase productivity Elimination of defects in manufacturing process & Controls 4M1T Conditions, Elimination of cost losses / wastages cost improvements Elimination of cost losses / wastages cost improvements. Since the introduction of PM, the predecessor of TPM, to Japan in 1951, "Seiichi Nakajima" has dedicated over half century to influence the concept of PM and TPM as a leader, and continues to this day. In these days, increasing numbers of TPM Award winners in overseas evidence that over 50 years of his committed effort is a genuine and valuable dedication to not only the Japanese manufacturing industry but also for manufacturing industry al l over the world. Without his remarkable effort, TPM and manufacturing industry would not have been what it is today.

TPM is a unique Japanese systems of managerial expertise. Developed from PM preventive or productive maintenance) style of US in 1950s subsequently developed to its present state by JIPM Now, TPM promotes entire company structures every line of businesses and all parts of the world. TPM is implemented company wide. To eliminate these problem, Five pillars strategy (EPS), one of Total Productive Maintenance (TPM) strategies, is the metrical approach established by The Japan Institute of Plant Maintenance (JIPM) in 1971.

TPM gives concept of zero product defects, zero breakdowns and minimal losses and better operating and maintenance managements for the plant to practice with the principle of 5S, Autonomous maintenance, Kaizen, Planned maintenance, Quality maintenance, Training, Office TPM, and safety Health and Environment according to its objective. EPS also aims to increase availability and effectiveness of existing equipment in a given situation in many production companies, through the effort of minimizing input (improving and maintaining equipment at optimal level to reduce its life cycle cost) and the investment in human resources which results in better hardware utilization and, operation and maintenance managements.

This Paper experience the practical works of TPM Implementation of in Automotive Chain Manufacturing Industry. The main objective of this paper is to implement five Pillar Methodology to all Process in one Roof like RM storage, Stamping, Bush , Different Heat Treatment Process, Induction Hardening, Chain Assembly, Storage warehousing, Robotic Turning, Hobbing, Naming, Fine Blanking, Tapping, Debarring. In the part one all five Pillar are explained and approach taken for Implementation of is also mentioned. After that discusses the analysis of the idea before and after implementation of the TPM. Finally we given the conclusion of the case study.

2. TPM Implementation

2.1 Kobestu Kaizen (KK Pillar Activity)

Definition of KK :- To Improve the Operational efficiencies by systematic Monitoring and reducing the losses resulting in effective Utilisation of machines and manpower.

KK Pillar Mainly Focus & Aim on:

Production : To increases production / Hr by maximising utilisation of plant capacity through OEE improvement, focusing on major losses in the cell, increasing loading time & debottlenecking of cell's. To increases production / man by automation, eliminating add-on operations, reducing throughput time and based on approved offloading. * Reduce lead time by reducing no. of processes, mfg. stages, waiting time transportation time.

Cost: To reduce manufacturing cost by improving material yield & reduction of conversion cost by identifying and elimination of cost losses and introduction of new processes. To reduce WIP by reducing the imbalance in production rate of different cell of same model.

"Kaizen" literally means "change for the betterment". Kaizen involves small improvements and is carried out on a continual basis and involving people of all level in the organization. The principle behind Kaizen is that "a very large number of small improvements are more effective in an organizational environment than a few improvements of large value". This pillar is aimed at reducing losses in the workplace that affect our efficiencies. By using a detailed and thorough procedure we eliminate losses in a systematic method using various Kaizen tools.

Table1: Details of Implementation Report Kobestu Kaizens

Cell	Parameter	Theme	Problems	Rootcause	Kaizen Idea	Countermeasures	Results
Fine Blanking Division	OEE	Reduce the setting time on Chamfer/ Tapping / Naming (SPM) M/C	Drill and Tap head removal time from machine is more	Need to remove and fix the head on machine	No need to Remove the Heads.	Marking Provided on machine to adjust the Pitch by Loosing the bolt of Drill & Tap Head without Removing both head from Machine.	Set up change Loss from 144.5 to 73.9minutes
		Reduce the setting time on Chamfer/ Tapping / Naming (SPM) M/C	Pitch setting time is more as need to remove twin heads and to set pitch with Pitch setting fixture Outside of Machines.	No Reference Masters for setup change on Machines	Reference masters on machines	Master Provided to set the pitch with locating pin on machine itself	Set up change Loss from 213.4 to 110.9 minutes
		Reduce the setting time on Chamfer/ Tapping / Naming (SPM) M/C	Setup time for Naming punch setting required is 1.11 Hrs.	Difficult to Locate the Punch as per Naming reference.	Easy to Locate punch as per naming reference	Provided the Reference Slots to punch with the reference of Naming as per part Drawing	Set up change Loss from 60.43 to 29.55 minutes
Rear Sprocket Div.		To Reduce Tool Change loss on Hobbing	More time Required to Change the set up on bottleneck Hobbing machine.	Online Hob set up Activity (On machine)	Offline Hob set up Activity. (Offline Activity)	Fixture & Mandrel for Offline activity Provided on Hobbing	Tool Change Loss change Loss from 38 to 10 minutes
Fine Blanking Division		To reduce the tool change Occurrences fine blanking tool by Increasing Tool Life	Fine Blanking Punch tool change OCC Blanking Punch Bulging and Chip Out	low Resistance strength to withstand	high Resistance strength to withstand.	Provided Alcrona – Pro coating to Punch with before and after polishing and lapping & Nitrating to resist bulging and chip out phenomenon.	Tool Change Occurrences reduce from 39 nos to 24 nos
Fine Blanking Division		To reduce the tool change Occurrences fine blanking tool by Increasing Tool Life	Die insert outer root dia. wear out and results in OPD oversize.	Heat treated surface is in direct contact with moving or rubbing parts.	No Direct Contact of heat Treated surface with Moving or Rubbing parts.	Alcrona – Pro coating Provided to die insert surface to increase the strength to withstand the rubbing force by avoiding direct contact of heat treated surface with moving elements.	Tool Change Occurrences reduce from 39 nos to 24 nos
Chain Assembly Lines		To eliminated Minor stoppages time/Occurrences of Locating pin struck up.	More occurrences/shift of Minor stoppages due to Locating Pin Struck up.	More Clearance	Less Clearance.	Provided the Single Locating Cartridge with Less clearance instead of four locating Barrel.	Minor Stoppage reduce from 7 Seconds to 0 sec/Occ
		To Eliminate Minor Stoppages occurrences of Conveyors due to Chain Assly Accumulation.	More occurrences/shift of Minor stoppages due to Chains accumulated on conveyer belt.	No any indicator to alert to visual inspector	ACIS Conveyor belt full Alarm	proximity sensor Provided to gives feedback to alarm and alarm alert to visual inspector. when chain accumulated on belt	Minor Stoppage reduce from 7 Seconds to 2 sec/Occ
		To Reduce the Minor stoppages due to pin feeding delay.	More nos of Occurrences/shift of Minor Stoppages due to pin stuck up.	Dust in pin	Air jet to remove dust	Air Jet Provided On Drum Conveyors.	Minor Stoppage reduce from 6 Seconds to 2 sec/Occ
		To Reduce the Minor stoppages due to pin feeding delay.	More nos of Occurrences/shift of Minor Stoppages due to pin stuck up.	Difficult to remove struck up Component from Conveyor block	Easy to remove struck up Component by Modifying conveyor block	Provided the Required Shape & Ground on Surface Grinding Machine of Conveyor blocks	Minor Stoppage reduce from 175 Seconds to 2 sec/Occ
Fine Blanking Division	Production/hours	To Increase the output / hours in heat treatment (SQF) FPD.	Fixture weight is 250Kg so average quantity per charge is 3192 Nos(One change require 8 hrs to complted)	More weight (250 Kg) of fixture	Less Weight (250 Kg) of fixture	Provided the material of new base tray with modification in tray base Grid Tray for by Using SS 310 material instead of HU grade for the Gear link . Mow the weight of base tray is 200 kg	Production/ Hours Improvement from 396 to 515 nos
Rear Sprocket Div.	Output/ Man/shift	To increase the Output/man /shift of Drilling machines.	Total 18 operators required in drilling cell	Line Layout of drilling Cell (one Man one Machines layout)	Cell (one Man two Machines layout) Layout of drilling Cell .	All 17 Nos Drilling Machines Layout Modified (one Man two Machines layout)	7 Nos Manpower saved
Packing Cell	Labour Cost reduction	To Reduce no. of Operator at packing Cell .	Total 26 operator are required at packing cell	Manual packing	Semi Automated Packing Line	Provided a facility of Semi Automated Kit packing .	Labor Cost Reduce by 8.4 lack/annum
Rear Sprocket Div.	Consumable Cost reduction	To reduce Consumption of Cutting Oil (Cut 55) In RSD	Cutting Oil Consumption In RSD Is 6000 ltr/month	Oil & Burr Separation not Possible .	make Oil & Burr Separation Possible	Provided the Oil Extraction machine for Extracting the Oil From Burr	Cutting Oil Cost cost reduced by 65 Lack/annum
Heat Treatment		To Reduce Consumption of Quenching Oil of sanyung Furnace	More consumption 5500 ltrs/month of Quenching Oil of sanyung furnace .	No Filtration of used quenching oil	: Quenching Oil Filtrations	Used Quenching Oil filtered with the Help of external Filtration machines.	Quenching Oil Cost reduced by 50 % per years
Rear Sprocket Div.	Tool Consumtion Cost	To Reduce Consumption of Inserts in CNC OD Turning Machine.	More Consumption Of inserts in Robo CNC Turning machines	Can not use remaining two Corners of Inserts.	Can use remaining two Corners of Inserts.	Modified Tool Holder Provided to use not used Corner of facing Operation for OD Turning Operations	Reduced Consumption Cost of Inserts by 9.65 lack per year
Rear Sprocket Div.		To Reduce Consumption cost of Inserts in CNC Turning	More Consumation of Inserts	No alternatives Design for tool holder to use other options for inserts	No alternatives Design for tool holder to use other options for inserts	Modified Tool holder Provided to use TNMG Inserts.	Reduced Consumption Cost of Inserts by 5.76 lack per year

2.2 Jishu Hozen –Autonomous Maintenance (JH Pillar Activity)

Definition of JH :- The purpose of Autonomous maintenance is to teach operators how to maintain their equipment by performing daily checks, lubrication, and replacement of parts, repairs, precision checks, and other

maintenance tasks, including the early detection of abnormalities.

JH Pillar Aims to eliminate force deterioration of m/c. To maintain basic condition of machine. Enhance maintenance skills of workmen. To Achieve Zero Breakdowns, Defects & Accidents, this is not being achieved due to weak JH. and to change the mind set of operator from. "I operate, you maintain" to "I operate, I maintain"

7 Steps of JH Pillar

0. The Beginning - preliminary step 1.Initial clean-up 2.Countermeasures against Sources of Contamination and Difficult to Access Areas 3. Formulation of Tentative Standards 4.Overall Inspection 5.Autonomous Inspection 6. Standardization 7. Autonomous Management.

7 1s Implementation

Figure 1: 1s-2s Activity

Figure 2: 1s-2s Implementation

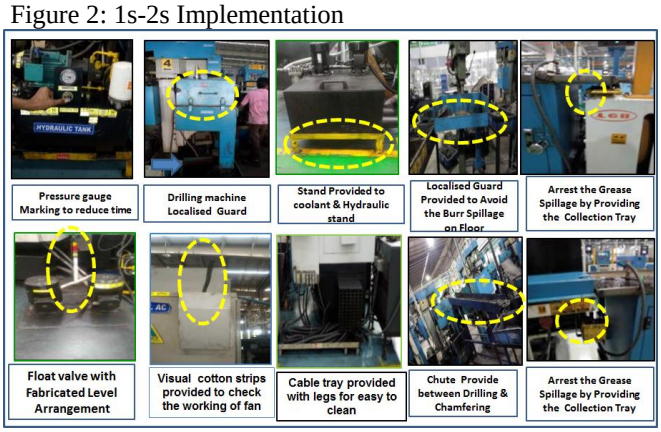


Fig No. 1.2 JH for JH step-3

1.Operators are given training by shop floor in charge in a pair of two about daily maintenance.

2. Earlier helper use to clean the machines, and they are not cleaning it regularly, as a result of which lots of work is accumulated during preventive maintenance.

3. In Step -2 Activity 6281 nos of Red Tag Abnormalities including SOC, Hard To CLIRt Identified and Removed through maintenance. 2475 nos. White Tag Identified & Removed by production Department.

4. Operator and helper are cleaning machine from its top and now they are responsible to upkeep the machine on which they are working.

5. Completed the Step-o3 on total No. of 142 machines.

6. With the help of maintenance department, shop floor in-charge and manuals of all machines, Autonomous Maintenance CLIRt Standard & Check list is prepared Now following this checklist is mandatory for all the operators. It is a responsibility of shop floor in-charge to see that every operator fills up this check list.

2.3 PM Pillar Implementations

2.3.1 Why PM?

PM Pillar plays an important role in plant TPM industrial journey. it possesses a standard purpose to give uninterrupted production by sustaining optimal equipment condition at all times and standard activities to provide services to enhance the knowledge and skills of maintenance operators.

2.3.2 Aim & Backgrounds:

PM Pillar helps to achieve the organizational main objectives. The main objectives are to make zero breaks down, sustain zero breakdowns, to make zero defects due to equipment by ensuring the availability and reliability of equipment to get uninterrupted production.

2.3.3 Support to JH Activity

PM Pillar team removed all the abnormalities which has identified by Production.

2.3.4 Equipment Failure analysis and countermeasures.

- Minimize Breakdown Time. Our main motto is to minimize the maintenance cost by optimizing the equipment condition. When look on history of equipment, very high breakdown time occurs must maintain the equipment in optimal running condition so that we could maintain uninterrupted production.
- Controlling Breakdown Occurrences. B.D. Occurrences completely affects the production plan. So we must maintain the zero break down occurrence to get uninterrupted production. Actually break down occurs due to weak design , lack of skills , poor operating condition and unattended deterioration.

Table 2: Action on Breakdown

Sr. No.	Month	Machine Name	Sub Assly	Category	Physical Phenomenon	Action Taken	Countermeasures	Why-1	Why-2	Why-3	Why-4	Why-5
1	Sep-17	YG TECH 2	Cutting oil pump	Mech	PP Alarm on Zero	Pump Suction filter cleaned	Suction filter mounting position changed from vertical to horizontal & gap from bottom of tank increased by 200mm	Suction filter cleaned	Suction filter clogged	Accumulation of burr surrounding the filter	Vertical position & less gap (50mm)between filter & bottom of tank.	Weak Design
2	Jul-17	IH-2	Lubrication unit	ELEC	Lubrication motor burnt	Lubrication motor replaced	Lubrication tank position changed to avoid splashing of water on motor.	Lubrication motor replaced	Lubrication motor burnt	Water entry inside the motor	Splashing of water on motor	Weak Design
3	Oct-17	Rotary Furnace	Drive assembly	Mech	Driven sprocket & Bearing worn out	Sprocket & Bearing Replaced	Sprocket & bearing replacement point added in TBM sheet.	Sprocket & bearing replaced	Sprocket & bearing worn out	Natural Deterioration		
4	Aug-17	CNC Robo 6	Robo	ELEC	Ground fault error on screen	Communication cable replaced	Water leakage from roof arrested.	Communication cable replaced .	Cable short	Water entry inside cable connector	Leakage from roof	Poor basic condition
5	Dec-17	Aeromech Hobbing	Spindle	MECH	Component clamp declamp error	Sensor mounting bracket replaced	Existing sensor mounting bracket was 6mm replaced the same with 10mm bracket	Sensor mounting bracket replaced	Sensor mounting bracket got bend.	Sensor mounting bracket thickness was less (ie 6mm)	Weak Design	

2.3.5 Preventive Maintenance

Machine wise PM Planed Prepared & PM done as per Schedule. Whatever PM abnormalities observed during the PM activity must closed immediately.

TBM Methodology

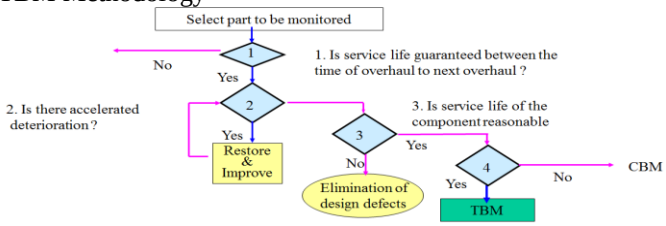


Figure 3: TBM Methodology

Base on TBM Methodology TBM calendar Prepared & executed.

2.3.6 Maintenance cost

Optimization of production and minimizing the cost is the main motto of each and every industry.PM pillar provides a planning to maintain optimal equipment condition with minimum maintenance cost.

Table 3: Kaizens Maintenance spare cost Reduction

Sr.No	Machine	Sub Assly	Problem	Improvement	Manufacturer cost	Actual cost	Cost Saving/Year
1	AIDA Press	Operating stand	Costly Touch Screen of AIDA Press	Same display procured (Import to Indigenous)	141500 /-	35000 /-	1.06 Lac One time
2	Mori Press 1 & 2	Heat exchanger	PM to be done at out source	PM done by developing in-house facility.	36000/-	8000/-	56000 /Year
3	Sanyung 1 & 2	Heat exchanger	PM to be done at out source	PM done by developing in-house facility.	36000/-	8000/-	56000 /Year
4	Aida Press 1 & 2	Component Conveyor	Conveyor S.S. sheet bend	Replaced the Piece of bend sheet by alternative source.	90000/-	12500/-	2.34 Lac/ 2 year
5	CNC Twin Turn, Robo, OD Turn	Chip conveyor	Chip conveyor gear box premature failure	Chip conveyor gear box replaced by high rpm one.	19000	12000	35000(5 nos) One time
Total savings							4.77 Lac.

2.3.7 Energy cost Reduction

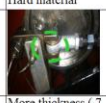
Table 3: Summary for Energy Saving Kaizen

Area	Kaizen Theme	No of Kaizens	Saving in Rs.
Plant shop floor lights	To save energy by timer based	36	45360
Rear sprocket	To save energy by hyd motor in auto off mode	01	3600
Sanyung furnace 1 & 2	To save energy by using minimizing job change over time.	02	525000
Sanyung furnace 1 &2	To save energy by using amp adjustment	02	230000
Water tank	To save energy by using water level sensor	02	8400
Total in saving			812360

2.3.8 MTTR and MTBF

It play a role of reverse characteristics i.e. when MTTR is very high while MTBF is low. Hence more time and cost on breakdown maintenance. Following the Some Major kaizens done in plants.

Table 4: MTTR Kaizens Implement

Parameter	Theme	Problems	Rootcause	Kaizen Idea	Countermeasures	Results
MTTR Kaizens	To increase the life of preheating fan assembly line	Preheating fan assly life is 2 months.	 Soft material	 Hard material	To provide SS (HU) grade for shaft & fan blades.	Maintenance cost reduced
	To Increase Life of Bronze washers of Bush Curling Machines	Bronze washer life is only 8 days.	 Less thickness 5 mm.	 More thickness (7 mm)	Provided 7 mm thickness Bronze washer	Maintenance cost reduced
MTTR Kaizens	To Increase Life of Bronze washers of Bush Curling Machines .	Bronze washer life is only 8 days.	 No access	 Access	To change the position of diaphragm rear to front.	Machine availability increased.
	To reduce PM time of Carriage Pneumatic. Cylinder read switch (Link & chain Assly lines)	More time (25 Min) for read switch PM	 No access	 Access	To provide slot on carriage guard.	Machine availability increased.

2.4 QM Pillar Implementations

Definition of QM: -To Produce the Defect free Product & Install sustainable systems for Defect Preventions.

It is geared towards achieving customer satisfaction through delivery of highest quality product. Through focused improvement defects are eliminated from the process after identifying the parameter of machine which affects the product quality. Transition is from Quality Control to Quality Assurance. Approach: The condition is checked and measured in time series to verify that measured values are within standard values to prevent defects. The transition of measured values is watched through charts to predict possibilities of defects occurring and to take counter measures before hand.

2.4.1 EFR & Warranty

There is no Accepted warranty & EFR Complaints from customer. So Proactive activity done as follows

Table 5: Proactive EFR & Warranty study

Sr no	Stages	Defect/phenomena	Prevention action plan	Frequency
1	Input	Material composition / dimensional variation	Supplier RM TC verify to LGB standard	Every lot
			RM chemical & Mechanical property test (as per plan)	Every New Heat
			Dimensional Inspection	Every Lot
2	Process	HT properties variation	Process parameter audit	Quarterly
			Process validation	Six month
		Assembly dimensional variation	Process parameter audit	Quarterly
			Process validation	Six month
3	Output	Functional parameter	Tensile test	Daily
			PDI report	Every Lot
			Wear test	As per Plan

2.4.2 Customer Complaints

Why-Why Analysis done of all customer complaint analysis in customers 6w2h format on all Customer.

Following Action initiated to avoid the Customer Completed

- Counter-measures on components arrested at Final inspection stage.
- Poka-Yoke daily check sheet
- PDI operator recognition

- Possible Customer Complaint Study
- IPO updated for defined actions & followed (IPO displayed in all lines).

Q-defect mapping for possible customer complaint

Table 6: Q-Defect Mapping

Q Defect Mapping

Sl.No	Customer Name	Chain Type	Defect Phenomenon	Observation	Root Cause	Defect Occuring Process	Corrective Action & Remarks	Corrective Action Responsibility	Date of completion	Implementation Status	HD Status
1	Bajaj	Drive Chain	chain lock position wrong	Chain lock in opposite direction .	1. Operator unawareness 2. End closing done manually.	End closing	1.Chain Locking proper positioning (Direction) training given to all operators. 2. End closing only by m/c. 3. Poka-Yoke available for correct position end closing.	Kapil Kurundkar	03.05.2016	Action Completed	YES
2	Bajaj	Drive Chain	Fitment issue	Chain Mixed up (122 links chain mixed up in 124 links)	Transporter Driver keep material in wrong location	Despatch	We had provided required training to the unloading people & drivers about unloading details.	Venugopal K.	20.07.2016	Action Completed	YES
3	Bajaj	Drive Chain	Short Link	Short Link	Wrong pitch cutting	Pitch Cutting machine	1. Pokayoke added (after manual pitch cutting chain will go to defect box) 2. Training provided to Operator 3. Chain Weight is monitored (inprocess 5' shift & 100% before final packing)	Kapil Kurundkar & K. Venugopal	04.07.2016	Action Completed	YES

2.4.3 IHR prevention Activities implement as follows

- Captured the defect phenomenon of process
- Prepare the QA matrix to understand the generating points
- Stratify the defect as A, B (B-poka & B-chronic), and C Type
- Analyze by doing why why analysis for A, B (poka) and C type phenomenon. Make the kaizen or poka yoke for arresting the defect at source.
- Carry out PM (P- Means Physical Phenomenon & M-Means Mechanism) analysis and simulation study for B (Chronic) type defect phenomenon. Make a kaizen or poka yoke for identified causes. Identify the 4M1T conditions
- Combine, make a plan for sustenance for ensuring zero defect status with the help of QM Matrix
- Maintain as per QM matrix or update the same if required.

2.4.4 Sustenance of Zero In-House Defects.

Zero IHR sustained through implementation of IPO methodology.

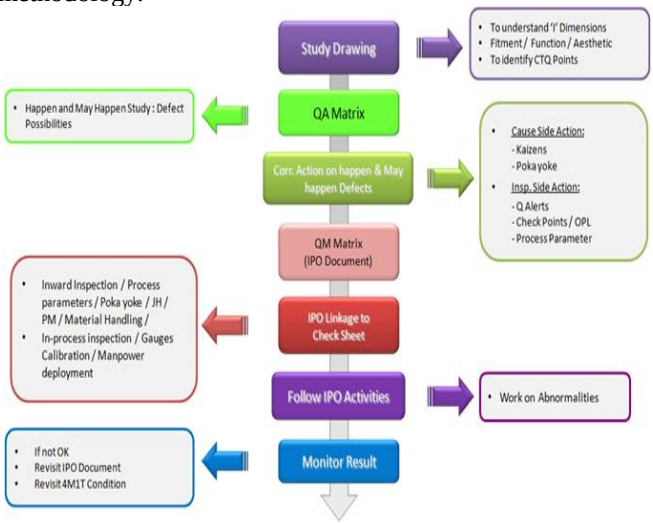


Figure 4 : IPO methodology

As per methodology Drawing Study Conducted, QA Matrix Prepared, Defect Possibilities Matrix Prepared, 4M1T Survey Conducted , QM Matrix prepared. Finally IPO Prepared and Linkage with Poka yoke Checksheet, JH Checksheet, Parameter Check sheet Inward Inspection Check sheet, PM Check sheet & inspection Check sheet.

2.5 Safety Health & Environment (SHE):

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Definition of SHE: - To Create Green Hygienic & Safe Workplace.

Aim of SHE

S :- To create safety awareness amongst the employees at work place, To achieve & maintain zero accident factory by continuous improvement & participation/involvement of employees To create awareness for the safe usage of equipment's

H **:-** Creating awareness amongst the employee towards maintenance of Health & Hygiene

E :- Prevention of Air, water & Soil pollution., Preventive Measures towards Norms led down by

Pollution Control Board & as per the Act

Definitions of Accidents :

Major Accident : Man days lost from workplace more than 48 hours. **Minor Accident:** Person injured is prevented from working for period of less than 48 hours. **First Aid injury Accident:** Injured person returns to work immediately after administration of first aid.No man-days lost.

2.5.1 Safety : Safety petrol Audit Conducted to Capture the Unsafe Condition/Unsafe Condition /Near Miss Cases to avoid the accident. Same 470 nos of Unsafe Condition, Unsafe Act 63 nos are identified. Some Action Initiated as follows.

Table 7: Action on Unsafe Condition

Sr.No	Unsafe Act	Location	Responsibility	Action Taken	Target Date	Status
1	Kone cran operator not wearing Safety Helmet while working	Hopper Area	Govind Chavan	Awareness Training Given for importance of use of PPE's on Shop floor	2/09/2017	Completed
2	Over storage of chain assembly in the bin	Infront of Rework Area	Mayur Madan	Marking done on bin for Maximum storage of Chains in Bin	2/09/2017	Completed
3	Possibility of accident while crossing the forward moving strip	Stamping	Sominath Sormare	Barricade Provided to restrict man movement.	3/09/2017	Completed
4	No usage of PPE's	Heat Treatment	Vivek Sura	Awareness Training Given for importance of use of PPE's on Shop floor	3/09/2017	Completed
5	Operator not use hand gloves on daily basis for handling chain	520 Line	Vivek Sura	Enforcement Done on usage of gloves On Daily basis	2/09/2017	Completed
6	While removing chain from hot greasing unit , operator not using hand gloves	520 Line	Vivek Sura	Proper Full length high temp. Resistive rubber hand gloves provided	5/09/2017	Completed
7	Safety belt & Helmet not wear on height more than 1.6 meter by electrical contract worker	Front of chain assly	Abhishek	Enforcement done & warn, him for cancellation of his work permit .	3/09/2017	Completed
8	Operator not use ear muff in pre running area	Pre Running	Mayur Madan	Training given for use of PPE	2/09/2017	Completed
9	ACIS OLM machine safety door not always closed	Line 2 & 5	Mayur Madan	Awareness about closed safety door done	3/09/2017	Completed

Table 8: Action on Unsafe Act

Sr.No	Unsafe Act	Location	Responsibility	Action Taken	Target Date	Status
1	Kone cran operator not wearing Safety Helmet while working	Hopper Area	Govind Chavan	Awareness Training Given for importance of use of PPE's on Shop floor	2/09/2017	Completed
2	Over storage of chain assembly in the bin	Infront of Rework Area	Mayur Madan	Marking done on bin for Maximum storage of Chains in Bin	2/09/2017	Completed
3	Possibility of accident while crossing the forward moving strip	Stamping	Sominath Sormare	Barricade Provided to restrict man movement.	3/09/2017	Completed
4	No usage of PPE's	Heat Treatment	Vivek Sura	Awareness Training Given for importance of use of PPE's on Shop floor	3/09/2017	Completed
5	Operator not use hand gloves on daily basis for handling chain	520 Line	Vivek Sura	Enforcement Done on usage of gloves On Daily basis	2/09/2017	Completed
6	While removing chain from hot greasing unit , operator not using hand gloves	520 Line	Vivek Sura	Proper Full length high temp. Resistive rubber hand gloves provided	5/09/2017	Completed
7	Safety belt & Helmet not wear on height more than 1.6 meter by electrical contract worker	Front of chain assly	Abhishek	Enforcement done & warn, him for cancellation of his work permit .	3/09/2017	Completed
8	Operator not use ear muff in pre running area	Pre Running	Mayur Madan	Training given for use of PPE	2/09/2017	Completed
9	ACIS OLM machine safety door not always closed	Line 2 & 5	Mayur Madan	Awareness about closed safety door done	3/09/2017	Completed

Table 9: Near Miss Cases

Sr.No	Problems	NMC	Location	Identified date	Identified By	Action Taken	Responsibility	Remark	Target
1	While Loading the Coil on Minster Press fall Down below the Tiltmatic , Person just escape from injury	Near Miss Condition	Stamping	10.12.2016	Mr Petchippan	MS Channel Provided to increase resting Size of Coil.	Mr.. Petchiapan	Completed	N/A
2	While doing clamp de clamp manually on SPM M/c operator unknowingly put hand on flapper but other person immediately removed his hand from flapper.	Near Miss Condition	F.P.D	07.07.2017	Mr Bhagyesh	Training given to concern persons	Mr.Bhagyesh	Completed	N/A
3	While working on OD M/c operator put hand unknowingly on nearby door .when door closing time other person removed his hand from door	Near Miss Condition	Rear Sprocket	14.09.2017	Mr Kishor kawale	Sensor Provided	Mr.Bhagyesh	Completed	N/A
4	While Operating Chain Assly Line Bush Thrown Away near to operator Head	Near Miss Condition	Chain Assembly	17-10-2017	Mr Bhagyesh	Acrelick Guard Provided	Mr.. Kapil Kurundkar	Completed	N/A

1 Sufficient number of fire extinguisher is provided all over CNC shop floor.
2.Training is given to each and every individual about how to use fire extinguisher in case of emergency in every 6 months.
3 Management is given suggestion for giving training to employee what to do in case of emergency? What should be the exit plan? Management is also given suggestion to conduct mock drill once in a year.
1.Earlier water camper in the shop floor was washed weekly now helpers are advised to wash it within 2 days.
2. Workers are advised to maintain cleanliness of toilets, regular cleaning of toilets is also done.
3. Workers are also advised not to chew tobacco and spit it in CNC shop floor and not to smoke within company premises.

2.5.2 Heathy

1.Earlier water camper in the shop floor was washed weekly now helpers are advised to wash it within 2 days.
2. Workers are advised to maintain cleanliness of toilets, regular cleaning of toilets is also done.
3. Workers are also advised not to chew tobacco and spit overall shop floor and not to smoke.
4. Also Medical health Checkup Conducted. In Medical checkup no one found affected occupational disease. Acoustic provided to avoid sound Pollution.

Also Survey Taken for Poor ergonomic condition & Poor Unhealthy Condition. Some of Survey taken as follows

Table 10: Survey for Poor Ergonomic Condition

	Machine/Stage	Poor Ergonomic Condition Available					Action	Target
		Bending	Body Twisting	Body Stretching	Weight Lifting	Walking		
F.P.D	SQF	N	N	N	N	N	Duct System Provided	Completed
	SQF(Near Unloading)	N	Y	N	N	N	Table Provided	Completed
	Strething M/c	N	Y	N	N	N	Table Provided	Completed
	Chamfering Naming & Taping	N	Y	N	N	N	Table Provided	Completed
	ID Debring	N	Y	N	N	N	Table Provided	Completed
REAR SPROCKET	Vibro Polishing	N	N	N	N	N	Ear Plug And Nose Mask Provided	Completed
	Chamfering (5)	N	N	N	Y	N	Table Provided	Completed
	Induction Hardning	N	Y	N	Y	N	Mask, Table And Plug Provided	Completed
	Debring	N	Y	Y	N	N	Supportive Table Provided	Completed
PACKING	Packing	N	Y	N	N	N	Supportive Table Provided	Completed
	Packing(Hooper)	N	N	N	Y	Y	Vertical Skate Provided	Completed

Table 11: Survey for Healthy Conditions

	Machine/Stage	Poor Healthy Condition Available						Action	Target
		Noise	Fumes	Dust	Hot Temp.	Low/High Illumination	Hazardous Chemicals		
F.P.D	SQF	N	Y	N	Y	N	N	Duct System Provided	Completed
	SQF(Near Unloading)	N	N	N	N	N	N	-	Completed
	Strething M/c	N	N	N	N	N	N	-	Completed
	Chamfering Naming & Taping	N	N	N	N	N	N	-	Completed
	ID Debring	N	N	N	N	N	N	-	Completed
REAR SPROCKET	Vibro Polishing	Y	N	Y	N	N	N	PPE Provided	Completed
	Chamfering (5)	N	N	N	N	N	N		Completed
	Induction Hardning	Y	N	N	N	N	N	PPE Provided	Completed
	Debring	N	N	N	N	N	N	PPE Provided	Completed
PACKING	Packing	N	N	N	N	N	N	-	Completed
	Packing(Hooper)	N	N	N	N	N	N	-	Completed

2.5.3Environment

Green Initiatives taken to increase the Green Zone of Company & Achieved up to the 33 % of total Premises. Various test conducted to maintain the environment Condition.

Table 12: Test Plan to maintain the Environment

S. No	Work	Frequency
1	Stack Emission Test	Yearly
2	Ambient Noise Test	Yearly
3	Waste water Test	Yearly
4	Hazardous waste disposal	Quaterly
5	Soil Test	Yearly
6	Tree Plantation	Progressive

3. Data Analysis

After Implementation of all Above five Pillar activity in All Process we observed following effective results includes Overall Effective implementations (OEE of Each Process & Division) as follows.

Table 13: Case Study results.

4. Conclusion

The key factors for this implementation are workers involvement and top management support. Still world class TPM implementation is possible with continual support at all the levels along with the supply of necessary resources. also number of Kaizen increase at the rate of 2 man/employee/month. Also Completed the 142 nos of Machines in JH Step -03.

Following conclusion is derived from implementation of TPM in the Chain manufacturing Industries of automotive company:

1) Success of TPM depends on various pillars like 5-S, Jishu Hozen, Planned Maintenance, Quality maintenance, Kaizen, Office TPM and Safety, Health & Environment.
2) Overall Equipment Effectiveness has improved from 63% to 85% indicating the improvement in productivity and improvement in quality of product.
3) Production/Hours/Output/man Improve by 30 % and Manufacturing Cost reduce by 20 %
4) Customer Complaints reduce & Sustain below 100ppm and In-house rejection reduce by 80 %.
5) Delivery Adherence Sustain by 100 %. & Accident reduce by 70%

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