International Journal of Engineering & Technology, 7 (2.33) (2018) 491-495

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper



Zero defects through P-M analysis -A case study

C. Gnanavel [1] *, R. Saravanan [2], M. Chandrasekaran [2]

[1] Assistant Professor, Department of Mechanical Engineering,Vels Institute of Science, Technology & Advanced Studies, Chennai,
[2] Professor , Department of Mechanical Engineering, Vels Institute of Science, Technology & Advanced Studies, Chennai,
**Corresponding author E-mail: gnanavelmech1986@gmail.com*

Abstract

Chronic losses – smaller, frequent deviations that gradually have been accepted as normal, live up to their name by resisting a wide variety of corrective measures taken in this regard. The persistence owed to reasons like failure to understand their nature and usage of ineffective approaches in dealing them. Tracking down their caused can be arduous as they rarely have just one cause, and conventional measures have become ineffective. This calls for evolution of new conceptual tools. In this paper P-M analysis, a rigorous improvement methodology that supports the pillars of TPM such as equipment improvement (KOBETSU KAIZEN), quality maintenance (HINSHITSU HOZEN) and plant maintenance have been applied for eliminating chronic losses. A typical illustration is provided through a case study conducted in a fastener manufacturing industry.

Keywords: *Zero Defects; Quality Maintenance; Chronic Losses.*

1. Introduction

Maintenance enhancement of product quality and assurance of homogeneity have become important tasks of production activities. These circumstances call for a quality assurance system with quality maintenance activities. Such as system should be aimed at approaching quality problems from plant maintenance and should act as center pillar of Total Productive Maintenance (TPM), upholding "assuring upkeep and enhancement of a huge – level of quality by effective equipment maintenance" as the basic idea.
The quality maintenance activities include setting the condition of zero defects and to check in time series, prevent quality defects and watch the transition of measured value to predict possibilities of defects and take counter measures beforehand. Hence it is evident that the basic philosophy should be "maintaining perfect equipment in order to maintain perfect quality" i.e., zero defects.

1.1. Basic concepts

Eliminating quality defects continue to be a major issue in the shop floor. Equipment failures and defects appears in two modes: chronic and sporadic losses. Sporadic losses are sudden, often large deviations from the norms, whereas chronic losses on the other hand are smaller frequent deviations that gradually have been accepted as normal. Chronic losses have higher resistivity to corrective measures and are products of complex tangled cause and effect relationships. Tracking of them is difficult as they rarely have just one cause. So it is difficult to eliminate them using the conventional effects. P-M analysis systematically clarifies chronic losses phenomena, identifies causal factors and guides improvement activities. The strength of the analysis is that it is not an "80/20" approach, the aim is zero chronic losses. This paper applies P-M analysis for improvement of a critical drilling process in a fastener manufacturing industry

2. Zero defect strategy

The demand for high- variety, low- volume short feed time production could be only achieved if manufacturing factory is kept with materials and products moving through smoothly, lead times should shrink and inventory must be minimized without disrupting the process, hence , the vitality of preventing equipment breakdowns and product defects is evident.
The zero defect or quality management formulated by Philip Crosby is given as follows:

1) The deviation of quality is in conformance of requirement.
2) The system of quality is prevention.
3) The performance standard is zero defects.
4) The measurement of quality is the price if non-conformance.

The goal of zero defect strategy is to create a means of promoting prevention – an essential element in the pursuit of quality. Since equipment failure is a type of defect, both zero defects and PM in effect are preventive systems aimed at eliminating defects.
The following precondition should be set for achieving zero quality defects.

1) Consider defect production a crime
2) Eliminate defects and failure.
3) Identify the quality required by customers.
4) Move from reduction of defects to elimination.
5) Preform inspection and checks.

The approach, which P-M analysis follows to achieve this strategy, is explained below.

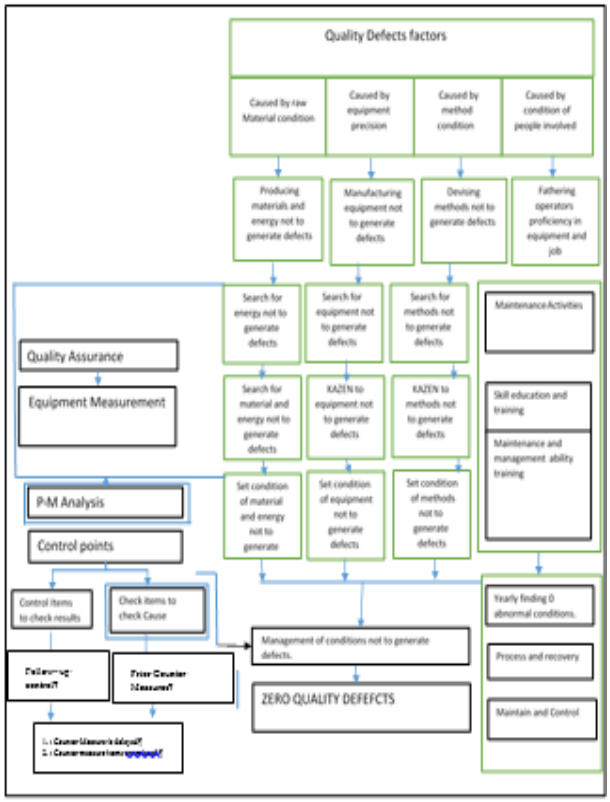
3. PM analysis methodology

P-M analysis is an advanced articulation of TPM. This eight step process has been proven to reduce chronic losses to zero and has

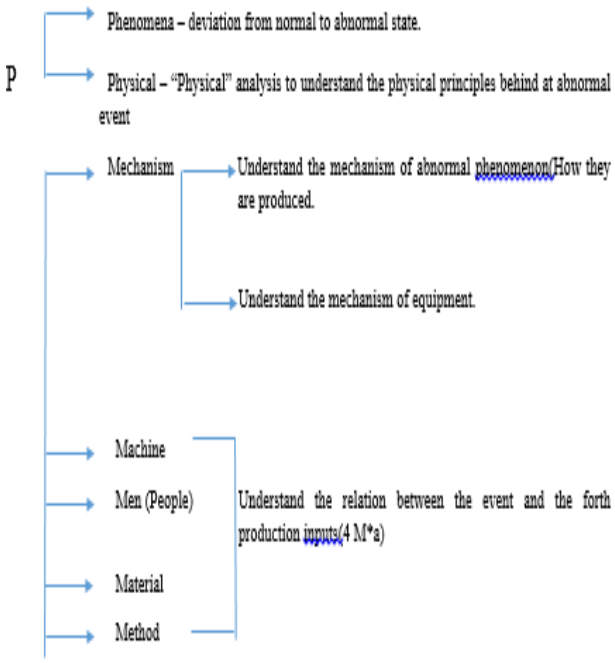
Copyright © 2018 C. Gnanavel et. al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

raised technological expertise in many manufacturing environments.

P-M analysis is more than a methodology as it is a different way of thinking about the problem and the context in which every they occur. The hinshitsu-Hozen concept is illustrated in figure 1.



The explanation fir P-M analysis is shown in figure 2.



The first four step in P-M analysis (refer figure 3) help us to isolate and understand the root cause of defects and failure within main equipment mechanisms and peripheral systems. The final four steps provide a systematic approach for effectively controlling those cause. The sequential steps of P-M analysis is shown in figure 3.

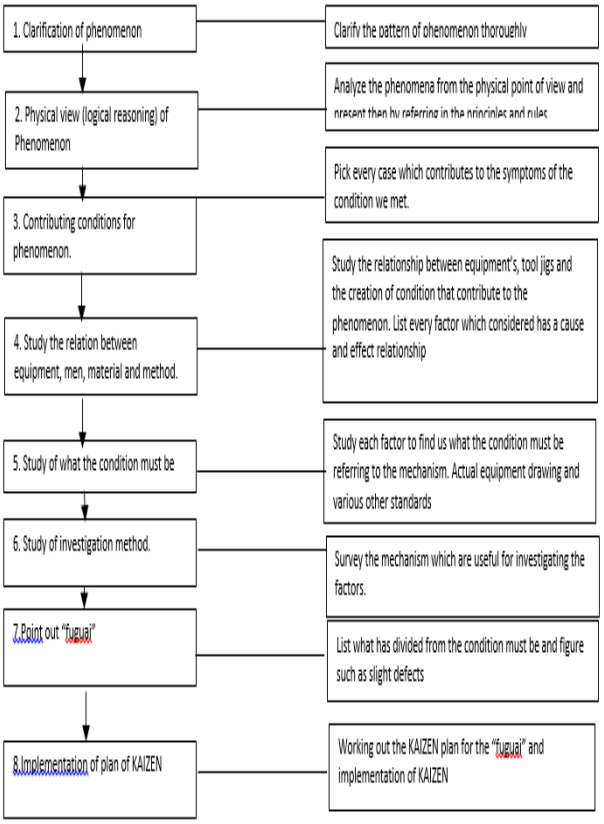


Fig. 2: Example of an Image with Acceptable Resolution.

3.1. The problem

The application of P-M analysis for improvement of manufacturing process is explained through a critical drilling process in fastener manufacturing industry. The process is critical as two holes are to be drilled on a bolt at an angular inclination, drilling of the second hole pose problems of the drilling tool.

The product defects caused due to this problem is the main focus of the case and P-M analysis is carried out to eliminate it

3.2. Methodology

The sequential approach is explained and the details highlighted. The problem was analyzed in two stages. The nature of problem is understood from the first stage. In the second stage the appropriate tool selection is made for the solving the problem identified from the first stage.

In the first stage, continuous samples of size hundred were taken to inspect the various quality characteristics. The results showed that 11th, 28th and 76th pieces were rejected on the basis of hole location undersize at the second hole's rear end due to various causes. From this it was concluded that the loss nature is chronic.

The second stage concentrates to solve the above said chronic losses. The appropriate tool recommended for eliminating chronic losses as per TPM strategy is P-M analysis.

Understanding the physical view of the phenomena makes the staring of P-M analysis. The Operating principle of drilling operation is as follows. While drilling is rotating it should be pressed to enable the drill and chisel edge to remove the material from the work piece and expel the material through the drill grooves. A band around the drill perimeter provides a hole guide and helps the drill penetrate in a straight line. After understanding the physical phenomena, the operating standards are to be fixed.

Operating standards:

1) Turn the drill are the specified RPM and check for absence of evenness and wobble.
2) Make sure that the drill's cutting edges are of the same shape and size all around. (Check the drill length and angle).

3) Make sure that the spindle moves in a straight line.

Next step in P-M analysis is to understand the contributing conditions of the phenomenon. The following observations were found.

- Spindle drive mechanism

The motor drives the pulley having major diameter and the drive is transmitted through a V-belt to the spindle having collect chuck and then to the drill.

- Feed mechanism
- The Feed mechanism is given by hand feed.
- Drill chuck.

It is a three- jaw chuck provided with grippers. The drill bit is held rigidly by means of grippers.

- Bush

The bush guides the drill to begin a hole in a solid piece which is mounted on the jig at an appropriate position.

- • Jig

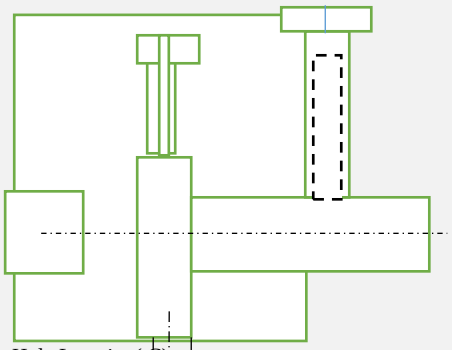
The product is to be places in the jig and clamped on the thread rolling diameter face i.e., side of the bolt, before the drilling operation. The jig is fixed with the workable using fasteners. The detailed steps of the P-M analysis carried out are shown in Charts 1 and 2.

Chart 1 P-M analysis Steps (1 to 4) Fuguai Item Drill Hole Defects. o/s: Over Sizeu/s: Under SizeAll dimension are in mm.

Chart 2, P-M analysis Steps (5 to 8) “Fugual” Item: Hole Location

In the chart no.2 the abnormal conditions were identified and corrective measures have been taken. Statistical analysis was carried out on the machine conditions before and after applying TMP strategy, i.e., P-M analysis. The outcome of the statistical analysis was obtained using SPC software and is shown as figures 4 and 5. The following tables I and II show the results before and after the P-M analysis. The tables gives the hole location dimensions at second hole’s rear end of product no M1653.

Table 1:

Phenomenon	Physical Layer (logical Reasoning)	Contributing Condition	Relation with equipment, jig Tool. Material and method	
			Primary Item	Secondary Item
Hole Location Under size variation(At second Hule’s rear end) C=D<2.8 mm	There is variation in (C) in distance (D) between the drill axis of the drilling machine and product reference position.	1.Drill center of rotation fluctuation	1.1 Drill fixing is to proper – M1	1.1.1 Lack of education and training 1.1.2 Improper method followed
			1.2 Collet of the is chuck worm out – M2	1.2.1 Prolonged usage of chuck or collet
			1.3 Drill spindle wobble – M2	1.3.1 Sleeve bore worn out 1.3.2 Spindle bearing failure
			1.4 Drill wobble while operation – M2	1.4.1 Unequal leaf length of re-grinded drill
			1.5 Wrong chuck used – M2	1.5.1 Oversize chuck is selected for gripping the drill
			1.6 Method of drill fixing is not proper – M2	1.6.1 Lack of education and training
		2.Drill guide bush inner diameter oversize or wom out	2.1 Guide bush fixing is not proper – M1	2.1.1 Lack education and training
			2.2 Drill center if rotation fluctuation – M2	2.2.1 Please refer in contributing condition 1
			2.3 Improper material selection for bush – M3	2.2.3 Material softer than drill(after heat treatment)
			2.4 Heat treatment is not proper – M4	2.4.1 Wrong heat treatment method selected for material selected.
Hole Location(C) M1 – Men M2 – Machine M3 – Material M4 – Method a) product b) Drill (Tool) c) Relationship between A and B d) Change in relationship		3.Improper product placement on jig	3.1 Improper product (job) loading – M1	3.1.1Negligancce of product Clamping. 3.1.2Not ensuring proper product placement.
			3.2 Burr in product placement area of the Jig – M1	3.2.1 Improper cleaning 3.2.2Burr on coolant
			3.3 Incoming material quality made poor – M3	3.3.1Burr in washer face. 3.32Excess washer thickness.
			3.4Jig – design is inadequate – M4	3.4.1 No way to ensure the right place of the product
			3.5 Improper cleaning procedure followed –M4	3.5.1Coolant force is only used for cleaning
		4.Quality of previous process is unstable	4.1 Incoming inspection is more done – M1	4.1.1Not found in sampling inspection of previous process
			4.2 forging defects – M3	4.2.1Not found in sampling inspection of previous process.
			4.3 Improper check procedure followed in incoming inspection –M4	4.3.1Lack of education and training for identifying forging defect
		5.Some standards are inadequate or not followed	5.1 Frequency of cleaning standards may be inadequate – M1	5.1.1Not once in a product placement
			5.2 Jig alignment changes –M1	5.2.1Inadequate retightening standards or negligence in retightening
			5.3 Jig and bush life is not fixed – M2	5.3.1Cannot be standardized
			5.4 Drill center axis fluctu-	5.4.1 Only visual measure-

					ation, range is not fixed – M2	ment may be followed			
					5.5 Machine vibration – M2	5.5.1 Excess hand feed 5.5.2Damaged belt			
					5.6 Standardization of incoming material is not done – M3	5.6.1 Lack of knowledge and skill in standardization			
					5.7 Uncalibrated gauges may be used for checking – M4	5.7.1 Duplicate gauges used for missed one. 5.7.2 Prolonged usage of gauges (old gauges)			

Table 2:

Checked Part	Check Item	Measuring Method	Tolerance	Measurement Value	Decision	Troubleshooting Method	Response
Spindle	Ovality	Dail guage	<= 0.05	0.02	OK		Hole diameter o/s
	RMP	Visual(cone pulley)	---------	----------	OK		Hole Offset
Chuck	Ovality at drill	Dial gauge	<=0.10	0.13	NOT OK	Replacement of collector chuck	Holelocation u/s or o/s
Drill	Length	Vemier cal per	57	57	OK	Should not use re-grinded drill	
	Diameter	Vemier cal per	2.3	2.29	OK		Hole diameter o/s
Jig alignment with machine	First hole location in the product	Dial gauge	4.2	4.13	NOT OK	Bush to be changed	
Clamp screw	Thread condition	Visual	Didn't slip	Didn't slip	OK		
Jig	Prefixed life	No. of holes drilled	200000 nos	113000 nos	OK		
Bush	Outer Diameter(new one)	Vemier calper	0.03	0.15	NOT OK	Sliding fit,so bush is to be clamped	
	Inner diameter	Pin gauge/Dial guage	2.3+0.06	2.3 + 0.09	NOT OK	Bush to be changed	
	Prefixed life	No of holes drilled	5000	4200	NOT OK	Proper heat treatment to be done.	
Product	Free from burr on washer face	Visual			OK		
	Washer thickness	Vernier caliper	<0.4	0.38	OK		
Clamp bolt of a Jig	Tightness	Visual mark / Re-tightening		Inadequate	NOT OK	Visual mark to be marked for ensuring tightness	
Product in Jig	Perfect loading	Visual			OK	Identification to be made for ensuring the prefect loading	Hole u/s
Drill fixing	Ovality	Dial guage	<0.10	0.13	NOT OK	Replacement of collector chuck	Hole diameter o/s
Coolant	Burr mixing	Visual	Free from burr	Burr found	NOT OK	Coolant to be filtered Properly	Hole location u/s
Inspection gauges	Pin gauge	Screw guage	2.3 – 0.01	2.3	OK	Calibration of gauges	Hole location u/s
Cleaning of burr	Jig and product cleaning	Visual	Free from burr	Small burrs found	OK	To use brush	Hole location u/s
	Frequency of Cleaning	Visual (Cleaning per product loaded)	1/1	1/10	NOT OK	Adhere the schedule	Hole location u/s
Clamping product	Negligence or inadequate clamping	Visual			NOT OK	To mark a visual match mark for ensuring the perfect clamping	Hole location u/s Hole offset

Table 3: Results before TPM for Product No M 1653

1	2	3	4	5	6	7	8	9	10
4.32	3.85	4.15	4.25	4.31	4.28	4.39	4.25	3.98	4.29
4.30	4.15	4.05	4.35	4.12	4.30	4.36	4.19	4.01	4.15
4.29	3.95	4.10	4.30	4.31	4.40	4.32	4.15	4.25	4.40
4.36	4.01	3.58	4.30	4.02	4.42	4.35	4.11	4.25	4.39
4.32	3.94	4.01	4.25	4.16	4.45	4.37	4.05	4.28	4.42
4.38	4.00	4.15	4.19	4.30	4.41	4.37	3.88	4.18	4.35
4.35	4.08	3.98	4.30	3.99	4.38	4.31	4.10	4.15	4.18
4.31	4.10	3.30	4.23	4.40	4.42	4.22	4.22	4.29	4.37
4.35	4.15	4.04	4.08	4.07	4.42	4.43	4.17	4.29	4.19
4.25	4.10	4.12	4.11	4.16	4.40	4.00	3.56	3.39	4.42

Table 4: Results after TPM for Product No M 1653

1	2	3	4	5	6	7	8	9	10
4.30	4.24	4.27	4.11	4.17	4.24	4.21	4.30	4.16	4.17
4.19	4.10	4.15	4.21	4.19	4.21	4.16	4.17	4.25	4.19
4.29	4.19	4.24	4.28	4.30	4.15	4.25	4.12	4.12	4.24
4.29	4.22	4.11	4.30	4.26	4.20	4.12	4.12	4.20	4.19
4.16	4.22	4.23	4.02	4.15	4.18	4.20	4.21	4.21	4.25

4.17	4.26	4.21	4.12	4.30	4.23	4.21	4.22	4.23	4.16
4.14	4.13	4.11	4.16	4.26	4.17	4.21	4.23	4.13	4.14
4.24	4.18	4.26	4.11	4.19	4.14	4.28	4.26	4.13	4.28
4.27	4.19	4.20	4.12	4.18	4.28	4.25	4.26	4.13	4.25
4.13	4.26	4.12	4.21	4.16	4.25	4.21	4.16	4.13	4.12

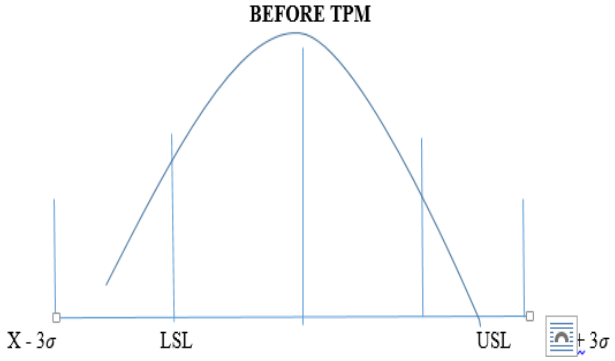


Fig. 4: Statistical Quality Control Analysis Results before TPM.

Process: Drilling
Product No: M 1653
Product Specification: 3/8" BSF Screw
Quality Characteristic: Whole Location
LSL =3.9500
USL=4.4500
NOM=4.2000
AVG=4.2145
σ= 0.1600
X-3σ=3.7344
X+3σ=4.6946
Cp=0.5207
Cpk=0.4905
Comments: * Process out of control
*Actual Rejection = 3%

From the figure 4 and 5 it can be observed that rejection has been completely eliminated and the process has been brought perfectly in control. The process capability index has been risen from 0.5207 to 1.5009.

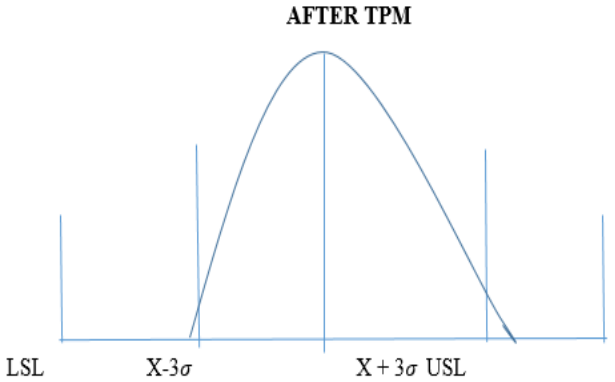


Fig. 5: Statistical Quality Control Analysis Results before TPM.

Process: Drilling
Product No: M 1653
Product Specification 3/8" BSF Screw
Quality Characteristic: Whole Location
LSL =3.9500
USL=4.4500
NOM=4.2000
AVG=4.2002
σ=0.0555
X-3σ=4.0336
X+3σ=4.3668
Cp=1.5009
Cpk=1.4997
Comments: * Processin control
* Actual Rejection = 0%

4. Conclusion

In this paper, total productive maintenance approach has been used to achieve zero – defects in a fastener manufacturing process. The drilling process in the part number M 1653 has been taking for analysis. P-M analysis has been done and tested successfully under quality maintenance concept (Hinshitsu Hozen). Implementation of these technique has resulted in the total progress of the quality rating of the industry.

References

[1] Kunio Shirose ET at, "Chronic Defects and failures, P-M analysis an advanced step in TPM implementation", productivity Press Inc., Cambridge, 1992.
[2] Mills, D, "Zero defects – a plan to achieve impossible", proceedings of 4th European Conference on Automated Manufacturing. IFS Publications, Bedford, 1994, pp 235-246.
[3] Nachi Fujikoshi, "Training for TPM Total Productive Maintenance". Productive Press Cambridge, 1990.
[4] Philips Crosby, "The Best Selling Quality is free", Mc Graw Hill Company, New York, 1979.
[5] Schneideman, A.M., "Optimum Quality costs and zero Defects" Are they contradictory concepts?" quality Progress, November 1986. Pp 28-31.