Preventive Action for Quality Improvement of the VTL Lamp in the End Process Quality Control (Study Case at a Lamp Manufacturer)

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ABSTRACT

Minor defect is a defect category that made to anticipate the types of potential defect. These preventive actions generate the increasing type and number of defect (there are more than 34 types of defect for minor defect and will continue to grow). Therefore, it's required a number of efforts to reduce the number of defect and to eliminate the types of defect.

MEDIC method is used to reduce the number of defect with high frequency of occurrence. We get 17 types of defect to be done, and then we identify the root causes that result 51 proposed solutions. From 51 solutions, 10 of them are implemented. As the result, the defect proportion of 11 from 17 defects are significantly reduced with α=5%.

The Deming Cycle (PDSA) method is used to eliminate the types of the defect with low frequency of occurrence from defect list. We get 14 types of defect to be eliminated. And then, for the trial period (11 days), we get 13 from 14 types of defect that will be proposed to be eliminated, because they have not emerged for the last 3 months and have passed the trial period.

Keywords

Preventive action, Minor defect, Occurrence's frequency, MEDIC, PDSA.

1. INTRODUCTION

"Quality is fitness for use" is a definition of quality by Joseph M. Juran. Quality must be maintained by a company in order to improve company's competitive advantage. Each company has to improve its product quality and process quality continually. There is no limitation for continuous quality improvement.

A company often focuses their quality improvement by doing a final inspection at the end of the production process. It seems too late, because the defective product will be detected at the end of the process, where all of the production's input has been used. This research focuses on the quality effort all along the production process, in order to prevent the defective product attain the end production process.

A lamp manufacturer, which produce VTL lamp, has four categories for their defect. They are as follow:

a. Critical safety defect, defect which is related to lamp user's safety.
b. Inoperative defect, defect which is related to the lamp reliability
c. Major defect, defect which influence customer's purchase interest.
d. Minor defect, defect which is tolerable but the company focuses on it, in order to maintain its product quality.

The focus of this research is on the minor defect because the number of minor defect is tending to increase. The objective of this research is to minimize several high frequency defect types and to eliminate several low frequency defect types from the minor defect list, at the end process quality control.

2. RESEARCH METHOD

This research follows MEDIC steps. The step can be seen at Figure 1. In the exploration and evaluation phase, the Deming Cycle is used to eliminate defect types with low frequency of occurrence. The application of Deming Cycle can be seen at Figure 2.

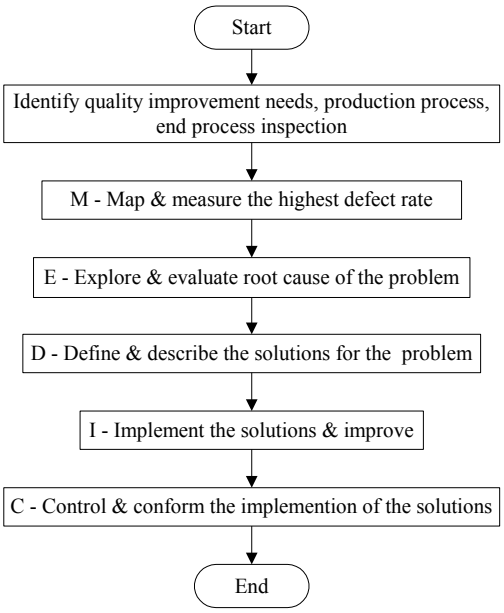

Figure 1: The MEDIC steps

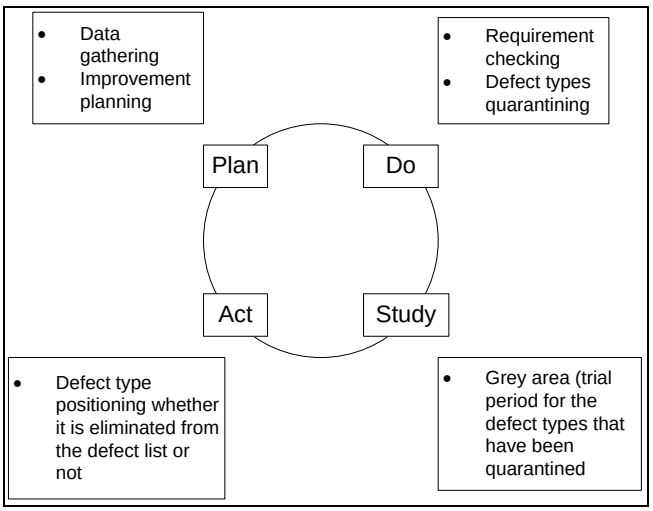

Figure 2: The Implementation of Deming Cycle

3. DATA ANALYSIS

3.1 Mapping and Measurement

The production division of the lamp manufacturer has eleven production processes to produce a VTL Lamp. They are as follow:

a. Washing and drying
b. Coating and drying
c. Oven sintering
d. Wiping and marking
e. Stem and mounting
f. Sealing
g. Pumping
h. Capping
i. Soldering
j. Flushing and testing
k. Packing

End process quality control is a quality control activity that is done at the end of production process (before packing). The objective is to inspect whether there is any defective VTL lamp or not, before the lamp is delivered to customer. The latest six month historical data from the end process quality control is used to find the highest minor defect rate. The data can be seen at Table 1.

Table 1: Historical data

Defect Type	Frequency
Foreign object	4
Mercury fleck	140
Swirling	108
Aslant cap	207
Cement waste	342
Knot 1	161
Dented cap	310
Unclear outer box's stamp	1
Unsticky tape	206
Loosen sleeve	113
Wrong packing date	5
Window	859
Powder off < 1 mm	65
Powder off 1-2 mm	63
Powder off > 2 mm	123
Dirty coating < 1 mm	90
Dirty coating 1-2 mm	30
Dirty coating > 2 mm	48
Pin hole	106
Rough coating	110
Stripe coating	98
Overflow 1/4 lamp's length	105
Air line glass	62
Defective glass	171
Fish eye > 10 mm	687
Fish eye < 10 mm	598
Blistered	230
Printed tape is sticky with the lamp	368
Long sleeve	72
Short sleeve	99
Clamp mark	58
Light stain	880
Motley	95
Glue stain	389
Wringkle	19
Aslant stel	59
No friction tape	11
Collide stel	16
Damaged sleeve	50
Damaged stel	2
High cap	31
Dirty tube	0
Blown	16
Bad sleeve	24
Folded seal	3
No coating	2
Thin coating	1
Glass stain	1
Sit high cap	1
Mire cap	4
Glass chips	1
Double sleeve	1
Flat lamp	1

Pareto Chart is built based on the data (see Figure 3). According to 80-20 rule, it can be seen from the chart that 80% defect types with high occurrence contains of 17 defect types. They are light stain, window, fish eye > 10 mm, fish eye < 10 mm, glue stain, printed tape is sticky with the lamp, cement waste, dented cap, blistered, aslant cap, unsticky tape, defective glass, knot 1, Mercury fleck, powder off > 2mm, loosen sleeve and rough coating. In the next step, these defect types will be analyzed, so they can be minimized in quantity.

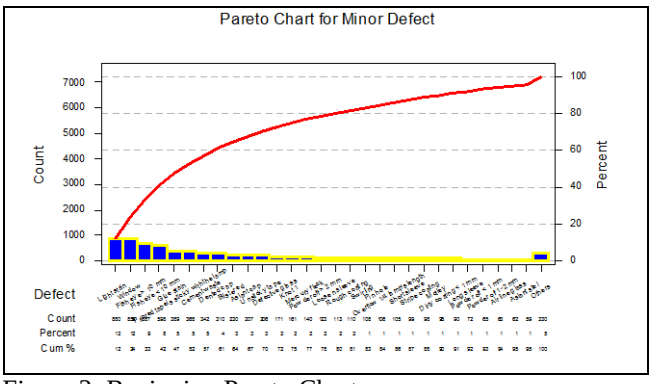

Figure 3: Beginning Pareto Chart

3.2 Exploration and Evaluation

3.2.1 Defect types with high frequency of occurrence

There are 17 defect types with high frequency of occurrence as mentioned before. In this phase, the root causes of all this defect types are explored using 5 WHY and Fault Tree Analysis (FTA). The objective of 5 Why is only to find the root causes of the problem, but the objective of FTA is not only to find the root causes of the problem, but also to find the relationship between the root causes. The example of 5 WHY and FTA for light stain can be seen at Table 2 and Figure 4.

Table 2: 5 WHY for light stain

No.	Problem	Why 1	Why 2	Why 3	Why 4	Why 5
1	Light Stain	Polluted suspension	Spray from cylinder air's oil	No cover at cylinder air's filter		
			Dew from cylinder air's oil			
		Unstable blast from drying blower	One or several butterflies are blocked	Saturated butterfly's filter at ducting		
			Unstable blast from segment 1-7	One or several butterflies are blocked by waste		
				Return pressure from segment 8-19		

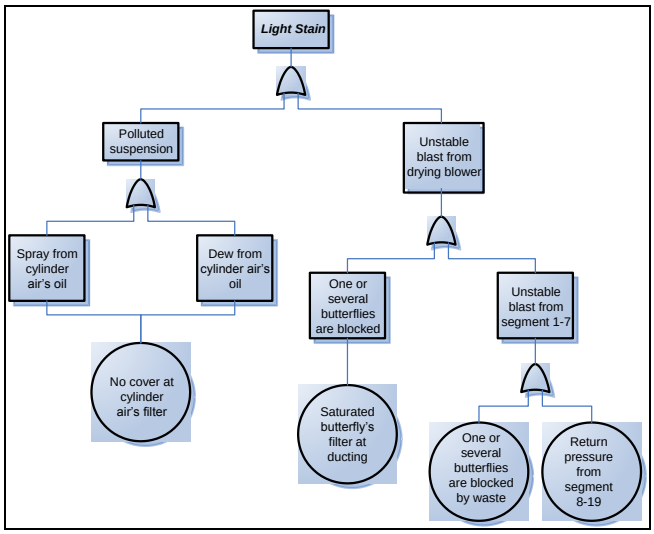

Figure 4: FTA for light stain

Totally, there are 49 root causes for the 17 defect types. The amount of root causes for each defect type can bee seen at Table 3.

Table 3: Number of root causes for each defect types

Defect Type	Number of Root Causes
Light stain	4
Window	5
Fish eye > 10 mm	2
Fish eye < 10 mm	
Glue stain	6
Printed tape is sticky with the lamp	7
Cement waste	3
Dented cap	4
Blistered	3
Aslant cap	2
Unsticky tape	2
Defective glass	1
Knot 1	1
Mercury fleck	1
Powder off > 2 mm	2
Loosen sleeve	5
Rough coating	1

3.2.2 Defect types with low frequency of occurrence

As mentioned before, Deming cycle is used to analyze defect type with low frequency of occurrence.

"Plan" phase has been done when the Pareto Chart was built. Some defect types with low frequency of occurrence can be seen from the chart.

In the "Do" phase, all of defect types are screened using four categories. They are as follow:

a. Process stability
   This requirement use Time Line Chart as a tool to examine the defect fluctuation and trend in the last three month, for defect types which have total number not more than 1 for the latest six month.
b. Customer requirement
   This requirement examine whether a defect type is included in the voice of customer or not.
c. Company requirement
   This requirement examine whether a defect type is included in company standard or not
d. IEC standard requirement
   This requirement examine whether a defect type is included in international lamp requirement or not.

As a result, there are 14 defect types that pass the screening. They are foreign object, unclear outer box's stamp, collide stel, damaged stel, dirty tube, folded seal, no coating, thin coating, glass stain, sit high cap, mire cap, glass chips, double sleeve, and flat lamp.

In the "Study" phase, 14 defect types enter the eleven days trial period, which is call grey area. If they can pass the trial period, which mean no defective item related with the defect types, then the defect types can be eliminated from the minor defect list. But if there is a defectives item related with them, they can not be eliminated from the defect list.

In the "Act" phase, the defect types' statue is determined, whether they can be eliminated from the minor defect list or not. The trial period result can be seen at Table 4. There are 13 defect types that pass the trial period, so they can be eliminated from the minor defect list. But there is only one defect type that fails to pass the trial period, which is unclear outer box's stamp. It can be seen that there are two unclear outer box's stamp in day 7.

Table 4: Trial period result

Defect Type	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11
Foreign object	0	0	0	0	0	0	0	0	0	0	0
Unclear outer box's stamp	0	0	0	0	0	0	2	0	0	0	0
Collide stel	0	0	0	0	0	0	0	0	0	0	0
Damaged stel	0	0	0	0	0	0	0	0	0	0	0
Dirty tube	0	0	0	0	0	0	0	0	0	0	0
Folded seal	0	0	0	0	0	0	0	0	0	0	0
No coating	0	0	0	0	0	0	0	0	0	0	0
Thin coating	0	0	0	0	0	0	0	0	0	0	0
Glass stain	0	0	0	0	0	0	0	0	0	0	0
Sit high cap	0	0	0	0	0	0	0	0	0	0	0
Mire cap	0	0	0	0	0	0	0	0	0	0	0
Glass chips	0	0	0	0	0	0	0	0	0	0	0
Double sleeve	0	0	0	0	0	0	0	0	0	0	0
Flat lamp	0	0	0	0	0	0	0	0	0	0	0

3.3 Definition and Description

As mentioned before, there are 49 root causes of 17 defect types. Through brainstorming, there are 51 proposed solutions; 10 of them will be implemented. They are as follow:

a. Modification of air cylinder sprayer filter.
   This solution prevents light stain, which is caused by suspension which is polluted by oil.
b. Additional cooling blower for tube which is come from oven sintering.
   This solution prevents window that is caused by tube which is not cool enough.
c. Additional automatic tool for suspension filling from offline to online,
   This solution prevents fish eye that is caused by bubble in the suspension which is flown from water base to production line.
d. Modification of glue needle.
   This solution prevent glue stain, that is caused by he position of the glue needle is change.
e. Modification of printed tape holding device.
   This solution prevent printed tape is sticky with the lamp, that is caused by the twisting position of printed tape.
f. Nozzle point modification by installing rubber seal.
   This solution prevents cement waste that come from turret cap filler.
g. Modification of cover tray.
   This solution prevents cement waste that is caused by dirty pin cap on the tray.
h. Additional upper holding device on the skater cap and turret meeting point.
   This solution prevents dented cap, which is caused by wide distance between skater cap and turret.
i. Glue viscosity study.
   This solution prevents unsticky tape that is caused by unfit dryness rate when the tape is assembled with the sleeve.
j. Socialization the new standard of suspension making process.
   This solution prevent powder off that is caused by less composition of material and prevent rough coating that is caused by less homogeneity of suspension.

3.4 Implementation and Improvement

The implementation has been done for a month at all line production. The result can be seen at Table 5. There is one defect type that the percentage after implementation is increased. It is loosening sleeve. After analyzing, it is known that supplier interface is needed to prevent this defect type. So it will become long term quality improvement for the company.

Pareto Chart after implementation can be seen at Figure 5. From the chart, it can be known that the defect types order is not the same with the beginning Pareto Chart. The highest defect type not light stains anymore, but window. Light stain is in the second order. In the third, the defect type not fish eye > 10 mm anymore, but change to cement waste, and so on.

Table 5: Implementation result

Defect Type	Before Implementation		After Implementation		Decreasing
	Number of cases	Percentage	Number of cases	Percentage	
Fleck merkuri	140	0.0201%	25	0.0134%	0.0067%
Aslant cap	207	0.0298%	19	0.0102%	0.0196%
Cement waste	342	0.0492%	70	0.0376%	0.0116%
Knot 1	161	0.0232%	12	0.0065%	0.0167%
Dented cap	310	0.0446%	49	0.0263%	0.0183%
Unsticky tape	206	0.0296%	45	0.0242%	0.0054%
Loosen sleeve	113	0.0163%	68	0.0366%	-0.0203%
Window	859	0.1236%	121	0.0651%	0.0585%
Powder off > 2 mm	123	0.0177%	21	0.0113%	0.0064%
Rough coating	110	0.0158%	24	0.0129%	0.0029%
Defective glass	171	0.0246%	10	0.0054%	0.0192%
Fish eye > 10 mm	687	0.0988%	66	0.0355%	0.0634%
Fish eye < 10 mm	598	0.0860%	68	0.0366%	0.0495%
Blistered	230	0.0331%	15	0.0081%	0.0250%
Printed tape is sticky with the lamp	368	0.0529%	40	0.0215%	0.0314%
Light stain	880	0.1266%	120	0.0645%	0.0621%
Glue stain	389	0.0560%	61	0.0328%	0.0232%
Total sample	695040		186000		

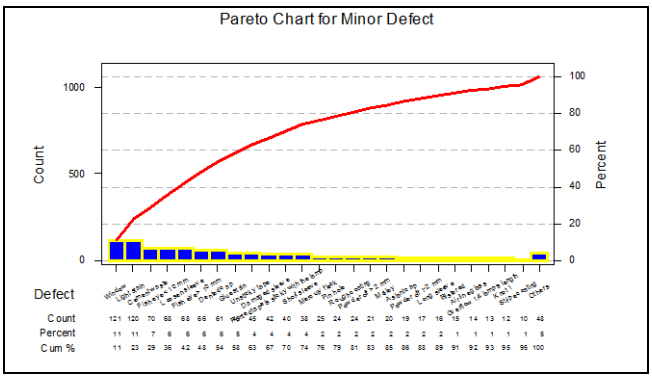

Figure 5: Pareto Chart after implementation

There is possibility that it is only order changing. A further analysis is needed. Two proportions test is done to find whether the percentage decreasing is significant or not ($\alpha = 0.05$). The result can be seen at Table 6. Among 17 defect types with high frequency of occurrence, there are 11 defect types which the percentage decreasing is significant. But the rest still not significant, include loosen sleeves which has a rising defect percentage after implementation. So, a continuous improvement is needed.

Table 6: Two proportions test

Defect Type	*P-Value*	Result
Light stain	0	Significant
Window	0	Significant
Fish eye > 10 mm	0	Significant
Fish eye < 10 mm	0	Significant
Glue stain	0	Significant
Printed tape is sticky with the lamp	0	Significant
Cement waste	0.096	Not significant
Dented cap	0.001	Significant
Blistered	0	Significant
Aslant cap	0	Significant
Unsticky tape	0.27	Not significant
Defective glass	0	Significant
Knot 1	0	Significant
Mercury fleck	0.065	Not significant
Powder off > 2 mm	0.052	Not significant
Loosen sleeve	1	Not significant
Rough coating	0.325	Not significant

4. CONCLUSION

There are 13 defect types with low frequency of occurrence that can be eliminated from the minor defect list, after the trial period. They are foreign object, collide stel, damaged stel, dirty tube, folded seal, no coating, thin coating, glass stain, sit high cap, mire cap, glass chips, double sleeve, and flat lamp.

There are 17 defect types with high frequency of occurrence that can be minimized. They are light stain, window, fish eye > 10 mm, fish eye < 10 mm, glue stain, printed tape is sticky with the lamp, cement waste, dented cap, blistered, aslant cap, unsticky tape, defective glass, knot 1, Mercury fleck, powder off > 2mm, loosen sleeve and rough coating. There are 51 proposed solutions, 10 of them are implemented. After implementation the defect types order at Pareto Chart is changed. Beside that, there are 11 defect types that decrease significantly.

REFERENCES

[1] Ariani, W. Dorothea, *Pengendalian Kualitas Statistik: Pendekatan Kuantitatif dalam Manajemen Kualitas*. Yogyakarta: Andi Offset, 2004.

[2] Dale, Barrie G., *Managing Quality* (2nd ed.). UK: Prentice Hall International, Ltd., 1994.

[3] Evans, J. R., and Dean, J. W., Jr. (2003). *Total Quality: Management, Organization and Strategy* (3rd ed.). USA: South-Western, 2003.

[4] Foster, S. T., *Managing Quality: An Integrative Approach* (2nd ed.). New Jersey: Pearson Education International, 2004.

[5] Garvin, D. A., *Managing quality: The Strategic and Competitive Edge*. New York: Macmillan, Inc., 1988.

[6] Groover, Mikell P., *Work Systems and the Methods, Measurement, and Management of Work*. New Jersey: Pearson Education International, 2007.

[7] Gryna, F. M., *Quality Planning & Analysis: From Product Development through Use* (4th ed.). New York: The McGraw-Hill Companies, Inc., 2001.

[8] Hunt, V. Daniel, *Managing for Quality: Integrating Quality and Business Strategy*. USA: V. Daniel Hunt Technology Research Corporation, 1993.

[9] Montgomery, Douglas C., *Introduction to Statistical Quality Control* (4th ed.). Singapore: John Wiley & Sons, Inc., 2001.

[10] Rampersad, Hubert K., *Managing Total Quality: Enhancing Personal and Company Value*. New York: The McGraw-Hill Companies, Inc. 2005