17

An Analysis on Minimization of Product Error (Poka-Yoke) and Excess Work in Progress (TPM & OEE) in Textile Industry

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Abstract: The rapid change in textile styles, deviation of order quantities and increasing quality levels at the lowest possible cut-rate, demand the textile manufacturing industry to be focused on more effective and efficient manufacturing processes for survival in an immensely competitive market. To increase the productivity of the textile industries we need to reduce the manufacturing defects and time to manufacture the product. Lean is the tool to reduce the wastage in all process of textile manufacturing, reducing cost and value added to the product. This paper proposes the lean tool like POKA-YOKE, DPMO, cause and effect diagram &OEE to reduce the overall product error and work-in-progress. Analysis covers the area of c poka - yoke which is any effort to eliminate human errors in the system. In short, Error=mistakes = defects. Therefore, the removal and control of errors eliminates defects. And specific section of sewing line was OEE is applied to investigate the existing condition of machine and provide recommendation to improve present condition in Classic Polo Textile industry to reduce work-in-progress.

Keywords: Cause and effect diagram, Defects, DPMO, POKA-YOKE, Rework, TPM & OEE.

1. Introduction

This study is carried out in classic polo private limited, Tirupur. This company comprises all departments like cutting department, sewing department, ironing and packing department all under one roof. The scope of the study is to reduce the product error and work-in-progress by applying lean manufacturing tool like POKA-YOKE, TPM & OEE to identify and eliminate product error, work-in-progress, the improvement of quality, and production time and cost reduction to provide a high-quality product without error to their customer by satisfying their requirements.

A. Need for the study

The major problem in classic polo is to reduce the product error and on time delivery. According to AQL chart the buyer may reject the entire product if one defect is in exceed than provided in the AQL limit and if there is time delay, they have sent the products through air instead of shipping which results in loss. Lean tool techniques are adopted to reduce this error and improve efficiency.

B. Objectives of the study

1) *Primary objective*
   - To Study about the minimization of the product error (Poka– yoke) and elimination of building excess Work in Progress (TPM&OEE) in Production Line.

2) *Secondary objective*
   - To know about Workload balancing to improve Output (cross functional team).
   - To Observe and analyze the various issue faced by textile industry.
   - To analyze the quality of the product (AQL).

2. Research Methodology

Descriptive research is defined as a research method that describes the characteristics of the population or phenomenon that is being studied. This methodology focuses more on the "what" of the research subject rather than the "why" of the research subject.
- To identify areas for further research
- To help in planning resource allocation
- To provide informal information about a condition.

A. Sources of data

The data will be collected from officials of the industry through interaction which are required for the completion of the project.

B. Instruments of data collection

The data are collected directly from the officials and employees by observation, questionnaires and interviews.

C. Primary data collection

The primary data will be collected from officials and employees through interviews and questionnaires.

D. Secondary data collection

The secondary data will be collected from the journals and literatures.

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18

3. Analysis and Interpretation

A. Regular average monthly production data

Table 1
Regular average monthly production

Confirmed piece	Rework piece	Rejected piece
1,30,000	6500 (4%-5%)	2600 (1%-2%)

B. Process in sewing section

Table 2
Process in sewing section

S. no.	Operating Functions	No. of operators
1.	Yoke surging	1
2.	Yoke label	2
3.	Bottom and Sleeve hemming	1
4.	Placket attaching	3,4
5.	Pocket stitching	2,3
6.	Shoulder stitching	1
7.	Collar join	1
8.	Sleeve join	2
9.	Side seam	2
10.	Slit stich	1
11.	Bottom labelling	1
12.	Peek	1
13.	Bar-tack	1
14.	Kaja, button stich	1
15.	Quality check	2

C. P-Chart

The quality level of the dress is based on Acceptance Quality Limit (AQL) chart. There are different limits like 1.5, 2.5, 4, 6.5. The AQL followed by most the buyers are 2.5. all the companies reject to accept the AQL 1.5 which us very difficult to manufacture. In 2.5 standard for 1000 pieces the checking quantity is 80 pieces.

Fig. 1. Acceptance Quality Limit (AQL) chart

D. Measure of DPMO

The term DPMO or defects per million opportunities is one of the important six sigma metrics. This value allows you to determine how effective your process is. It also allows for a comparison between processes. Similar to PPM or parts per million, DPMO provides a more in depth look at process effectiveness.

In this the percentage of defect, capability study existing DPMO of selected product was calculated.

Number of checked pieces =130000
Number of confirming pieces=123500
Number of non-confirming pieces=6500

DPMO= (Number of non-confirming items/ Number of checked items) *1000000
DPMO =50,000
Proportion of defectives = (DPMO/1000000)
Proportion of defectives= 0.05
Proportion of confirming unit= 1- 0.05 = 0.95
Percentage of confirming unit= 95%
Percentage of defect = 5%
Percentage of rework in last month is 5%

E. Cost of Rework

In garment industry reworking a piece of garment takes 3 times more than making on a first-time good piece. Having 6500 piece of rework is equivalent to stitching 6500*3 =19500 pieces at specific operation. So, the average time of operation for stitching a particular part is around 50 sec.so total time on rework is,

(SAM*Total number of rework)/50= (60*6500)/50=7800 minute. Average garment value for one operator for one minute is 0.62/min=7800*0.62 = 4836 Rupees.

Table 3
Cost of rework for a month

Rework	SAM	No of Rework*3	Time on Rework (min)	Garment Min value	Operator Cost for rework
Shoulder	33	1572	864.6	0.62	524.89
Neck rib	5	1026	85.5	0.62	53.12
Neck seam	38	2055	1301.5	0.62	806.93
Paste label	13	1239	268.45	0.62	166.43
Collar close	42	1794	1255.8	0.62	778.59
Hem sleeve	42	2379	1339.8	0.62	830.67
Sleeve stitch	58	1914	1850.2	0.62	1147.12
Side seam	56	2505	2338	0.62	1449.56
Peak	21	1641	574.3	0.62	356.06
Bar-tack	20	759	253	0.62	156.86
Hemming	42	2316	1612.2	0.62	988.5
Total					7258.73

The total amount wasted on rework for a month on rework is 7258.73.

F. Implementation of POKA-YOKE to reduce this product error and rework

Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur Poka-Yoke helps in developing a process or a system that enables quality to be built during the manufacturing process, while also authorizing operators to stop the line in case the product does not conform to the specifications.

Based on working methodologies, Poka-Yoke tool can be classified into following two types:

- Prevention based
- Detection based

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19

G. Prevention-based Poka-Yoke

Prevention-based mechanisms sense an abnormality that is about to happen, and then signals the occurrence or halts the process, depending on the severity, frequency or downstream consequences. There are two approaches for prevention-based Poka-yoke.

- Control Method
- Warning Method

H. Detection-based Poka-Yoke

Shop floor experiences have shown that detection- based Poka-Yoke can be implemented in three ways in apparel industry:

- Fixed Value Method
- Contact Method
- Motion step method

Following is the detail discussion of processes, manufacturing and the use of poka-yoke devices. If spinning, weaving and bleaching departments are automated, so there is less human involvement and less human error.

1) Spinning

The process starts with making thread from the cotton. cotton comes in as a raw material in the textile manufacturing. It takes processes to separate the dust from the cotton. The only thing to take care of is that the sliver thread does not break.

2) Weaving

Making fabric from the thread. Problem which usually occur are the needle breakage in looms, thread breakage, oil leakage, warp and weft defect and contamination occurs this is mainly due to the Operator negligence Hence this defect occurs, it is rectified by the worker. To further avoid the defects, operators are briefed. Operators full attention is needed to supervise the work of the machine, to ensure that machine is working properly.

3) Contamination in weaving

Contamination in weaving process cannot be removed except winding. In winding contamination is not visible my naked eye but it can be detected by optical clearing sensors and will be removed along with some yarn as waste material.it is beneficial to remove contamination before going to further process.

4) Stitching & Packing

Inline inspection is held Quality auditors check the stitching 3-4 times a day. They may include 1-inch auditing system to check all double stitch, skip stitch etc.

a) Stitch quality monitoring system

- They may install this for top AQL demanded products.
- Now-a-days there are automated dobby, automatic pick repair, automated wrap breakage locator to reduce human error.

5) Embroidery

Companies using 1st level poka-yoke were thread breakage is detected by Andon. Andon is a red-light bulb which lightens whenever thread breaks. As it lights machine stops at spot indicating about the particular section where the problems have occurred.

Fig. 2. Embroidery

The machine instead of requiring an operator to stand over them constantly observing them to ensure nothing went were instil with "intelligence" so that they stopped when something went wrong. By using this the operator may watch several machines than watching one which making it cost effective for company. It may also be an array of lights found on a single board that signals a team leader where abnormality found. Below diagram shows an Andon light turning red when defect is detected.
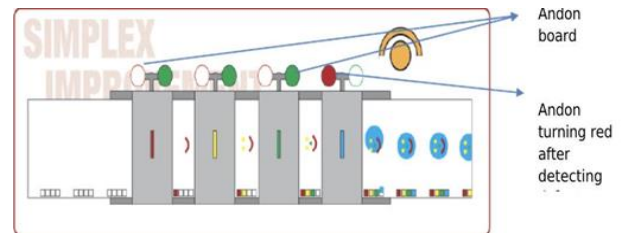

Fig. 3. Andon light

I. Metal detector

Fig. 4. Metal detector

Metal detector is used to find out any broken needles or any metals in the product in final checking to reduce the critical problems.

J. Cause and effect diagram

The cause and effect diagram for product error were drawn to identify the root cause of the problem and here the product error like skip stitch, stain, broken stitch is due to the lack of

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20

skill, Long time needle usage, improper machine usage and several factors were analysed. The critical cause of each acute defect of product was found through this cause and effect diagram.
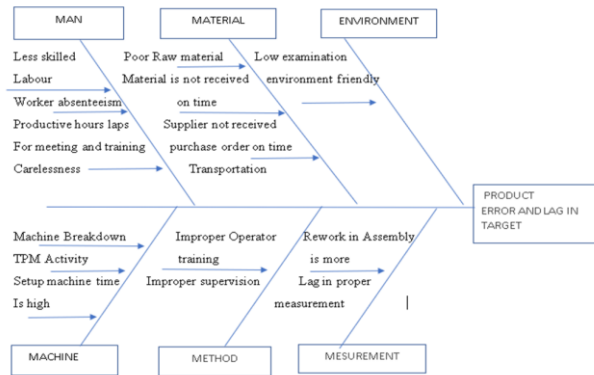

Fig. 5. Cause and effect diagram

K. Solution for the cause

To make sure sewing machine is properly maintained, Regular change in needle, Corrective setting of the machine to the cloth, observe sewing operation for better material handling and switching person depending on their speed and capability. There may be a piece rate instead of swift base to reduce time and product error.

Table 4
Instructions to prevent error

Product error	Solution
Wrinkle	1.Parts should be joined carefully 2. Heating of Fabric from specific distance can be effective
Wrong puller insertion	1. Advice operator to put more attention while inserting puller. 2. Alter operator for reducing monotonous.
Broken, skip stitch	1. Tension of bobbing cage and needle thread should be adjusted. 2. Advice to trim thread attentively.
Uneven stitch	A little more training and attention can solve this problem partially.

L. Total Productive Maintenance

TPM (Total Productive Maintenance) is a holistic approach to equipment maintenance that strives to achieve perfect production:

- No Breakdowns
- No Small Stops or Slow Running
- No Defects

In addition, it values a safe working environment:

- No Accidents

The objectives behind to adopt TPM

- Evade wastage in a rapidly changing economic environment.
- Manufacturing goods without dipping product quality.
- Attain Zero Defects, Zero Breakdown and Zero accidents in all functional areas of the organization.

1) Equipment effectiveness before application of total productive maintenance

In the manufacturing process there are defective product due to inefficient maintenance of the machine and machine breakdown which also leads to time delay. In order to satisfy customer, the product must be defect free. Defect free products requires machine without trouble. Before application of TPM there are breakdown of machine led to product error and poor customer satisfaction.

2) Equipment effectiveness after application of total productive maintenance

After implementation of TPM, the workers were educated at every level of production process about TPM, Labels and Signs in machine used to identify the machine that need special attention, remained operator to perform daily maintenance which improved their productivity and on time delivery due to non-breakdown of machine.

M. Overall Equipment Effectiveness (OEE)

OEE is the framework for measuring the efficiency and effectiveness of a process, by breaking it down into three constituent components (Availability, Performance and Quality product rate). It helps to measure a problem so that easily can fix it and provides a standardized method of benchmarking progress. OEE identifies the percentage of planned production time that is truly productive.

Overall machine or equipment efficiency is the how to performs machine versus spec. In practically,

$$OEE = Availability(A) * Performance(P) * Quality(Q)$$

1) Availability

Availability takes into account all events that stop planned production long enough where it makes sense to track a reason for being down (typically several minutes).

Availability = Run Time / Planned Production Time
Run Time = Planned Production Time − Stop Time

2) Performance

Performance takes into account anything that causes the manufacturing process to run at less than the maximum possible speed when it is running (including both Slow Cycles and Small Stops).

Performance = Net Run Time /Run Time
Net Run Time= Ideal cycle time* Total count

3) Quality

Quality takes into account manufactured parts that do not meet quality standards, including parts that need rework. Remember, OEE Quality is similar to First Pass Yield, in that it defines Good Parts as parts that successfully pass through the manufacturing process the first time without needing any rework.

Quality = Good Count / Total Count

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21

4) Overall equipment effectiveness analysis

Table 5
Overall equipment effectiveness

S. no.	Machine	Down time	Run time	Cycle time	Reject per day
1.	Over lock (shoulder join)	47	413	0.24	12
2.	Lock stich (neck rib tuck)	38	422	0.26	5
3.	Overlock (neck join)	48	412	0.29	9
4.	Flat lock (neck top)	46	414	0.28	5
5.	Lock stitch (back neck)	35	425	0.45	10
6.	Flat lock (sleeve hem)	43	417	0.50	13
7.	Overlock (sleeve hem)	32	428	0.48	6
8.	Flat lock (side seam)	52	408	0.68	10
9.	Lock stitch(tuck)	43	417	0.23	12
10.	Flat lock (body hem)	46	414	0.28	10
11.	Iron machine	25	435	0.55	3
12.	Metal detector	23	437	0.08	0

5) OEE calculation

The OEE of the selected production line is calculated. Here, shift time is 9 hours so 540 min, Scheduled break time is 60 min, planned production time =540 min, Non-scheduled break time is 20 min. Here the down time includes equipment failure, idling and minor stoppage, speed loss, defects (scarp and rework), start-up etc. The following table represents OEE condition of the selected production line of the selected floor.

The overall OEE level of the studied production line is 75.2 percent.

N. Findings

- It has been found that the average production per day is 18000 pieces.
- By applying DPMO rework rate was found to be 5% and rework cost was 7258.72 per month.
- The overall OEE level of the studied production line is 75.2 percent.
- Time consumption after following zigzag layout

and quality check in sewing section.
- Lack of training about machine pressure adjustment and proper machine service.
- Time delay in case of machine breakdown by shift workers.

O. Suggestions

- OEE can be increased by scheduled maintenance of machine before breakdown.
- Tension of bobbing cage and needle thread should be adjusted before every operation.
- Wrap and Weft errors are due to the machine which leaves any thread during weaving. There must be a use of automated stop units, which stops as it leaves any thread.
- As company has to prepare the order earlier due to urgency of the shipment, shade variation occurs. To avoid shade variation put a scale on the dryer let know the variation occur. When acceptable level of dryness is achieved during dyeing the process can be stopped.
- Color sensor are helpful in early detection of contamination which alarms the operator when error occurred.
- Automated machine can be installed for high quality AQL demand. Nowadays there are automated dobby, automatic pick repair, automated wrap breakage locator to reduce human error.
- Heating of Fabric from specific distance can be effective by using laser light.
- Maximum piece rate wages can be obtained to reduce voluntary time lag.

4. Conclusion

The most difficult thing in manufacturing is producing a right quality product for all the right time and work toward manufacturing a best quality product for good customer satisfaction, still it is important to work on improving product quality to satisfy customers, to control production cost and to save energy. From the study it is analyzed that the overall equipment effectiveness level of the taken production line is

Table 6
Overall equipment effectiveness percentage

Machine name	Total Production	Rejected Production	Availability %	Perform %	Quality %	OEE %
Overlock	1430	12	86.04	83.09	99.16	71.05
Lockstitch	1390	5	87.91	85.63	99.64	75.00
Overlock	1212	9	85.33	85.31	99.25	72.24
Flatlock	1237	5	86.25	83.64	99.59	71.84
Lockstitch	810	10	88.54	85.76	98.76	74.99
Flatlock	736	13	86.87	87.76	98.27	74.91
Overlock	760	6	89.16	85.23	99.21	75.39
Flatlock	495	10	85	82.5	97.97	68.70
Lockstitch	1567	12	86.87	86.42	99.23	74.49
Flatlock	1230	10	86.25	83.18	99.18	71.15
Ironing	740	3	90.62	92.28	99.61	83.29
Detector	4780	0	91.04	92.97	100	84.63
PRODUCTION LINE OEE %			88.01	87.46	98.24	75.2

75.2%. From the cause and effect diagram it is found that Improving product quality is generally not difficult, but requires deliberate and ongoing attention, and it requires the commitment of every individual within the manufacturing company, from the person who cleans the floors to the most senior manager. Manufacturing the quality product is mandatory to sustain in this globally competitive market. Therefore, it is very important to see to it that garments are made of high quality. Poka-yoke, TPM & OEE tools were applied to increase efficiency, reduce product error and work-in-progress to achieve a high-quality product. It plays an important role in maintaining the quality of clothes. Minimizing defect is very important for ensuring the quality of products.

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