# Developing A Total Preventive Maintenance (TPM) Plan For Flatlock Sewing Machines : A Case Study In The Apparel Industry In Sri Lanka

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## INTRODUCTION

The apparel industry faced considerable changes as a result of the removal of Multi Fiber Agreement in 2005. Delivering high-quality garments at low cost in shorter lead times are the major challenges faced by the apparel manufacturers. Most of the apparel manufacturers are trying to achieve these challenges successfully. In 2008, the global recession badly affected almost all the apparel manufacturing industries in the world. Due to recession, demand for low-cost garments increased by the customers. Suppliers were forced to deliver low cost garments. Because of the high-cost factor in Sri Lanka, most of the companies faced difficulties in getting orders and some companies closed down. The companies are seeking ways to minimize their cost in order to meet the competition by other low cost countries such as China and Bangladesh and to survive. In order to face this global challenge, most of the local apparel manufacturers have adopted different strategies. Total Productive Maintenance (TPM) is one of the techniques that is getting popular among local apparel manufacturers. It helps to minimize machine downtime as much as possible and by doing so, organizations can reduce their cost, improve on-time delivery, and also improve the product quality (Silva, 2011). TPM can be defined as a system that involves both shop floor associates and maintenance associates, supports the Lean Production System and keeps equipment in optimal condition (Brown, 2006).

## BACKGROUND OF THE RESEARCH PROBLEM

Well experienced professionals in the apparel industry say that there is a huge problem with Flatlock sewing machine breakdowns as compared with other sewing machines such as Single needle, Overlock etc. There are a plenty of opportunities that people can apply new maintenance techniques to reduce this problem. TPM is a relatively new concept to the Sri Lankan industries. As a result, there is derth of research that has been done on its suitability in the Sri Lankan context. In this paper, the author tries to come up with a maintenance plan, which can be used to maintain Flatlock sewing machines used in the apparel industry.

## PROBLEM STATEMENT

Based on the above explanation, a broader research problem can be stated as: *"How can TPM techniques be effectively used to maintain Flatlock sewing machines with minimum breakdowns?"*

## OBJECTIVES OF THE STUDY

In answering the research problem, the study sought to accomplish the following research objectives :

- To reduce breakdowns by 50% on Flatlock sewing machines in a chosen line;
- To reduce repair time of Flatlock sewing machines to < 5 minutes in all cases;
- To develop operator and mechanic checklists for Flatlock sewing machines;
- To develop a process for attending a breakdown in Flatlock sewing machines;
- To introduce a preventive maintenance plan (overhaul plan) for Flatlock sewing machines.

## LITERATURE REVIEW

- **Introduction To Total Productive Maintenance (TPM) :** In 1969, the ideas of TPM facilitated by Seiichi Nakajima,

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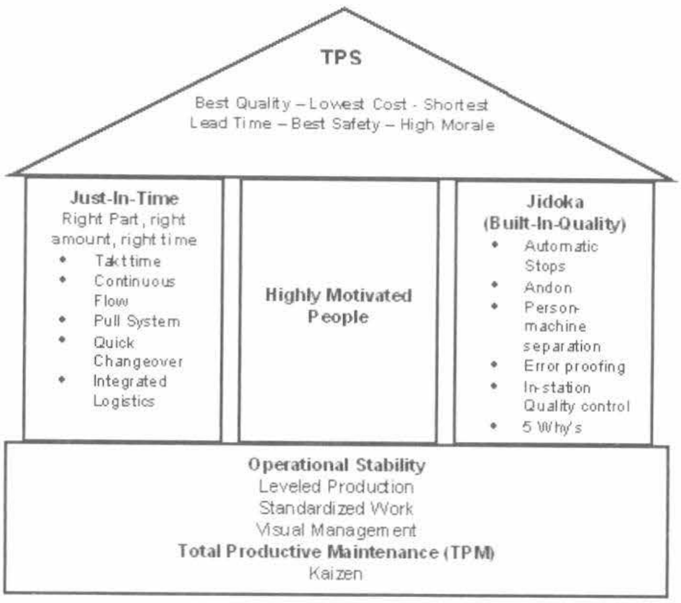
helped take the Toyota Production System (TPS) to the next level of *"TPS House"* (Figure 1). The foundation of *"TPS House"* diagram represents operational stability and has several tools, one of which is TPM. Organizations that want to become *"World Class"* need to implement TPM successfully.

**Figure 1: House of TPS (McBride, n.d.)**




TPM is a maintenance program concept, which focuses on minimizing downtimes and maximizing machine utilization. It is a new approach to plant maintenance that combines preventive maintenance with total quality control and employee involvement. Everyone's involvement is necessary in implementing TPM successfully in a company. TPM capitalizes on proactive and progressive maintenance methodologies, and calls upon the knowledge and cooperation of operators, equipment vendors, engineering and support personnel to optimize machine performance (Kilpatrick, 2003). The goal of TPM is to plan your downtime and reduce sudden breakdowns to a minimum. It can be further classified as to achieve :

**1.** Zero breakdowns.

**2.** Zero defects.

**3.** Zero accidents.

**4.** Total (100 %) employee involvement.

**5.** Achieve *takt time* at the highest machine effectiveness.

**Introduction To Seven Types of Abnormalities :** The Table 1 describes seven types of abnormalities with examples, which can be found in any type of machine.

**Introduction To Industrial Sewing Machines :** Industrial sewing machine was a turning point in the history of the industrial era. Industrial sewing machines are often designed with a single function in mind, which is different from home sewing machines. Industrial sewing machines changed the way clothing was made and more importantly, the speed at which the clothes could be produced. The origin of industrial sewing machines came from England, France and the United States of America. The first patent for an industrial sewing machine was in 1790 by a person called St. Thomas. This machine used to sew leather and fabric. It followed the action of copying the man's arm when sewing. In 1807, a new innovation by two Englishmen, William and Edward Chapman, came up with a machine with the eye of the needle at the bottom of the needle and not at the top. Isaac M. Singer developed the *"Singer sewing machine"* and that design received a patent in 1851. The main difference between this machine and other sewing machines is that it had an arm overhanging a flat table and dropped the needle down. This allowed any sewing direction (A brief history

**Table 1: Seven Types Of Abnormalities (Seven Types Of Abnormalities Poster, 2009)**

| No. | Abnormality | | Examples |
|---|---|---|---|
| 1 | **Minor flaws** | Contamination | Dust, dirt, powder, oil, grease, rust, paint. |
| | | Damage | Cracking, crushing, deformation, chipping, bending. |
| | | Play | Shaking, falling out, titling, eccentricity , wear, distortion, corrosion. |
| | | Slackness | Belts, chains. |
| | | Abnormal phenomena | Unusual noise, overheating, vibration, strange smells, discoloration, incorrect pressure or current. |
| | | Adhesion | Blocking, hardening, accumulation of debris, peeling, malfunction. |
| 2 | **Unfulfilled Basic Conditions** | Lubrication | Insufficient, dirty, unidentified, unsuitable or leaking lubricant. |
| | | Lubricant supply | Dirty, damaged, or deformed lubricant inlets, faulty lubricant pipes. |
| | | Oil level gauges | Dirty, damaged, leaking ; no indication of the correct level. |
| | | Tightening | Nuts and bolts : slackness, missing, cross-threaded, too long, crushed, corroded washer unsuitable, wing nuts on backward. |
| 3 | **Inaccessible Places** | Cleaning | Machine construction, covers, layout, footholds, space. |
| | | Checking | Covers, construction, layout, instrument position and orientation, operating - range display. |
| | | Lubricating | Position of lubricant inlet, construction, height, footholds, lubricant outlet, space. |
| | | Tightening | Covers, construction, layout, size, footholds, space. |
| | | Operation | Machine layout : position of valves, switches, and levers : footholds. |
| | | Adjustment | Position of pressure gauges, thermometers, flow meters, moisture gauges, vacuum gauges, etc. |
| 4 | **Contamination Sources** | Product | Leaks, spills, spurts, scatter, overflow. |
| | | Raw Materials | Leaks, spills, spurts, scatter, overflow. |
| | | Lubricants | Leaking, split, and seeping lubricating oils, hydraulic fluids, fuel oil etc. |
| | | Gases | Leaking compressed air, gases, steam, vapors, exhaust fumes etc. |
| | | Liquids | Leaking split and spurting cold water, hot water, half-finished products, cooling water, waste water etc. |
| | | Scrap | Flashes, cuttings, packaging materials, and non- conforming product. |
| | | Other | Contaminants brought in by people, fork-lift trucks, etc. and infiltrating through cracks in buildings. |
| 5 | **Quality Defect Sources** | Foreign matter | Inclusion, infiltration and entrainment of rust, chips, wire scraps, insects etc. |
| | | Shock | Dropping, jolting, collision, vibration. |
| | | Moisture | Too much, too little, infiltration, defective elimination. |
| | | Grain size | Abnormalities in screens, centrifugal separators, compressed - air separators etc. |
| | | Concentration | Inadequate warming, heating, compounding, mixing, evaporation, stirring, etc. |
| | | Viscosity | Inadequate warming, heating, compounding, mixing, evaporation, stirring, etc. |
| 6 | **Unnecessary and Non-urgent items** | Machinery | Pumps, fans, compressors, columns, tanks, etc. |
| | | Piping equipment | Pipes, hoses, ducts, valves, dampers, etc. |
| | | Measuring instruments | Temperatures, pressure gauges, vacuum gauges, ammeters, etc. |
| | | Electrical equipment | Wiring, piping, power leads, switches, plugs etc. |
| | | Jigs and tools | General tools, cutting tools, jigs, molds, dies, frames, etc. |
| | | Spare parts | Standby equipment, spares, permanent stocks, auxiliary materials, etc. |
| | | Makeshift repairs | Tape, string, wire, metal plates, etc. |
| 7 | **Unsafe Places** | Floors | Unevenness, ramps, projections, cracking, peeling, wear (steel deckplates). |
| | | Steps | Too steep, irregular, peeling anti-slip covering, corrosion, missing handrails. |

| | | | |
|---|---|---|---|
| | | Lights | Dim, out of position, dirty or broken covers, not properly explosion-proofed. |
| | | Rotating machinery | Displaced, fallen off or broken covers, no safety or emergency stop devices. |
| | | Lifting gear | Wires, hooks, brakes, and other parts of cranes and hoists. |
| | | Other | Special substances, solvents, toxic gases, insulating materials, danger signs, protective clothing etc. |

of industrial sewing machine, 2010).

A Serger is a separate machine from a standard sewing machine. Sometimes called *"Overlock machines"* or *"Merrowers"* (after Joseph Merrow), they use two or more threads and have a built-in mechanism that trims the fabric (Geiss, 2010a). First invented in 1881 by Joseph Merrow, in 1964, the Juki Corporation introduced smaller Sergers. Since then, sewing machine manufacturers including Singer have marketed separate Serging machines for home use. Flatlock is a type of Serged stitch. The Flatlock (flatstich) is a two-thread stitch that creates an unbulky, flat seam that practically disappears into fabric. Two-thread serging is also good for decorative edges. Often, the user can disable the knife while creating Flatlock seams. This stitch is best for knits and woven fabric (Geiss, 2010b).

## RESEARCH APPROACH

The study mainly employed a mix of qualitative and quantitative research approaches with the following research strategies.

- **Sample :** For the sample, one of the most expert plants in apparel manufacturing was selected judgmentally. The reason being the author was working as a permanent employee at the plant when the research was carried out. The plant had 20 production lines (bands), and 11 days of machine and needle breakdowns were taken as the base data.
- **Data Collection :** Data is collected through past machine and needle breakdown records. The Table 2 shows the data collected from 20 production lines from 25th August to 5th September 2010. Furthermore, *"5 Why"* techniques along with the Table 1 were used to identify the abnormalities of Flatlock sewing machines and to draw the Fishbone diagrams for main types of breakdowns.
- **Data Analysis :** The data gathered were analyzed using descriptive statistics. Fishbone diagrams were used to illustrate the relationships between cause and effect. Expert personnel from the production and maintenance departments also participated in developing the maintenance plans along with the researcher.
- **Validity And Reliability :** The research was done by collecting data from a well reputed apparel organization in Sri Lanka, and the researcher was participating in the real work environment. Thus, it leads to a conclusion that the data gathered is valid and reliable.

## FINDINGS AND DISCUSSION OF THE STUDY

As the initial step, the researcher collected the past machine and needle breakdown records from 20 production lines in the selected factory. The Table 2 shows the data collected from those lines from 25$^{th}$ August, 2010 to 5$^{th}$ September, 2010.

The following were the findings :

- Machine breakdowns = 72 = 0.65 BD/line/day (11 days in Line 1 to 10).
- Needle breakdowns = 664 = 3 NBD/line/day (11 days in Line 1 to 20).
- Total breakdowns = 3.65 BD/line/day.

In order to apply TPM concepts, the production line number 9 was selected based on judgmental sampling and the following steps were carried out.

**1) Initial Cleaning – Close Abnormalities :** As the first step, all the eight Flatlock sewing machines in the line were thoroughly cleaned and the abnormalities were found. Some were fixed (closed) then and there and some needed spare parts.

**2) List Of Abnormalities Which Cause Breakdowns :** In general, the following abnormalities were found in the inspected Flatlock sewing machines :

**Table 2 : Base Data**

| Date | 25 | | 26 | | 27 | | 28 | | 29 | | 30 | | 1 | | 2 | | 3 | | 4 | | 5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Band No.** | **MB** | **NB** | **MB** | **NB** | **MB** | **NB** | **MB** | **NB** | **MB** | **NB** | **MB** | **NB** | **MB** | **NB** | **MB** | **NB** | **MB** | **NB** | **MB** | **NB** | **MB** | **NB** |
| Band 01 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| Band 02 | 0 | 0 | 0 | 3 | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 4 | 0 | 1 | 2 | 2 | 2 | 1 |
| Band 03 | 2 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 4 | 1 | 1 | 1 | 0 | 3 | 0 | 5 | 0 | 6 | 0 | 2 | 0 | 3 |
| Band 04 | 0 | 2 | 0 | 5 | 0 | 2 | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 3 | 1 | 0 | 0 | 1 |
| Band 05 | 0 | 1 | 0 | 2 | 0 | 3 | 0 | 2 | 1 | 1 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 4 | 0 | 0 |
| Band 06 | 3 | 7 | 3 | 6 | 2 | 2 | 2 | 6 | 5 | 6 | 3 | 4 | 5 | 7 | 2 | 3 | 1 | 2 | 0 | 5 | 0 | 6 |
| Band 07 | 1 | 3 | 2 | 0 | 0 | 4 | 0 | 0 | 0 | 3 | 0 | 4 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 3 |
| Band 08 | 1 | 4 | 0 | 2 | 0 | 3 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 4 | 0 | 3 | 1 | 3 |
| Band 09 | 0 | 2 | 0 | 6 | 0 | 10 | 0 | 3 | 2 | 8 | 2 | 13 | 4 | 12 | 0 | 20 | 0 | 11 | 0 | 8 | 1 | 9 |
| Band 10 | 0 | 2 | 2 | 2 | 2 | 3 | 2 | 1 | 2 | 0 | 0 | 2 | 0 | 1 | 0 | 5 | 2 | 6 | 0 | 7 | 0 | 9 |
| Band 11 | 0* | 5 | 0* | 2 | 0* | 2 | 0 | 4 | 0 | 3 | 0 | 2 | 0 | 2 | 0 | 4 | 0 | 3 | 0 | 1 | 0 | 5 |
| Band 12 | 0* | 4 | 0* | 9 | 0* | 1 | 0* | 1 | 0* | 6 | 0* | 3 | 0* | 5 | 0* | 3 | 0* | 3 | 0* | 5 | 0* | 2 |
| Band 13 | 0* | 4 | 0* | 3 | 0* | 2 | 0* | 5 | 0* | 4 | 0* | 2 | 0* | 2 | 0* | 5 | 0* | 3 | 0* | 7 | 0* | 1 |
| Band 14 | 0* | 2 | 0* | 2 | 0* | 3 | 0* | 2 | 0* | 2 | 0* | 1 | 0* | 0 | 0* | 0 | 0* | 3 | 0* | 3 | 0* | 2 |
| Band 15 | 0* | 0 | 0* | 3 | 0* | 1 | 0* | 5 | 0* | 7 | 0* | 1 | 0* | 4 | 0* | 1 | 0* | 6 | 0* | 4 | 0* | 6 |
| Band 16 | 0* | 0 | 0* | 3 | 0* | 1 | 0* | 5 | 0* | 7 | 0* | 1 | 0* | 4 | 0* | 1 | 0* | 6 | 0* | 4 | 0* | 6 |
| Band 17 | 0* | 2 | 0* | 2 | 0* | 3 | 0* | 2 | 0* | 3 | 0* | 2 | 0* | 1 | 0* | 3 | 0* | 1 | 0* | 3 | 0* | 5 |
| Band 18 | 0* | 3 | 0* | 2 | 0* | 1 | 0* | 2 | 0* | 3 | 0* | 3 | 0* | 3 | 0* | 2 | 0* | 2 | 0* | 1 | 0* | 4 |
| Band 19 | 0* | 3 | 0* | 2 | 0* | 2 | 0* | 0 | 0* | 3 | 0* | 0 | 0* | 1 | 0* | 1 | 0* | 4 | 0* | 7 | 0* | 4 |
| Band 20 | 0* | 5 | 0* | 5 | 0* | 1 | 0* | 1 | 0* | 4 | 0* | 4 | 0* | 6 | 0* | 4 | 0* | 5 | 0* | 6 | 0* | 1 |
| Band 21 | 0* | 0 | 0* | 2 | 0* | 6 | 0* | 7 | 0* | 2 | 0* | 1 | 0* | 2 | 0* | 0 | 0* | 4 | 0* | 8 | 0* | 4 |

Source: Case company operational data * Not Tracked

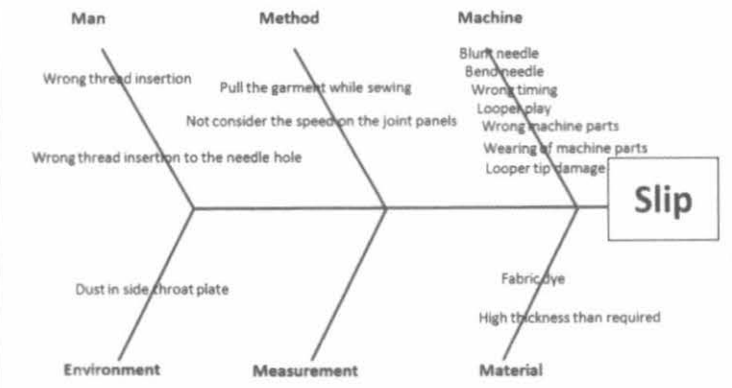
- Corrosion in thread guide;
- Looper play;
- Throat plate screw missing;
- Oil level not sufficient;
- Tension screw missing;
- Front needle guard missing;
- Oil leakages;
- Oil discoloration;
- Play thread stand;
- Wrong thread sizes;
- Dust on the looper.

**3) How To Prevent Abnormalities? :** A brainstorming session was carried out with the maintenance and production departments in order to identify the methods to prevent abnormalities. The following are some of the suggestions that came up after the session.

- Include the abnormality in mechanic/ operator checklist – by this method, regular checkups will be done and the occurrence of abnormalities can be prevented.
- Include it in the overhaul service plan – abnormalities which cannot be fixed during a daily maintenance checkup can be fixed during the overhaul service.

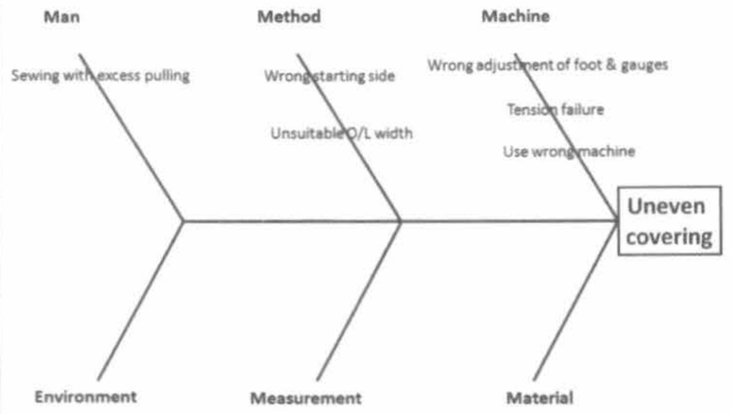
**4) Draw A Fishbone Diagram For Each Type Of Breakdown – Action For Each Cause :** Three types of major breakdowns were found in Flatlock sewing machines. i.e. thread slipping, uneven covering and needle breakage.

**Figure 2: Fishbone Diagram – Slip**



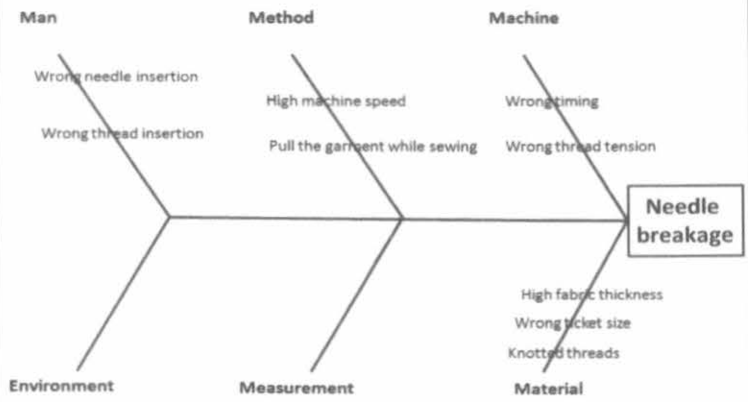

Source : Based on the researcher's observations and participants' insights

**Figure 3: Fishbone Diagram- Uneven Covering**




Source : Based on researcher's observations and participants' insights

**Figure 4: Fishbone Diagram - Needle Breakage**




Source : Based on researcher's observations and participants' insights

Then three Fishbone diagrams were drawn to identify the causes that occur due to man, method, machine, environment, measurement and material (Figures 2, 3 and 4).

**5) Develop Operator, Mechanic Checklists :** Based on the abnormalities found and causes captured from Fishbone diagrams, operator and mechanic checklists (Tables 3 and 4) were developed in order to prevent breakdowns in Flatlock sewing machines. In the operator checklist, some steps must be performed at the start of the shift, while the cleaning alarm rings at the end of the shift. In the mechanic checklist, some steps are performed at the start of the shift,

**Table 3: Operator Checklist**

| Responsibility - Machine operator | Brand No. ............ Month ............ Machine operator name............ Mechanic name : ............... | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Step** | **Time** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Check the thread tension and the sequence it has inserted. | Start | | | | | | | | | | | | | | | | | | | | | | | | |
| Check oil level. | Start | | | | | | | | | | | | | | | | | | | | | | | | |
| Check whether nuts and bolts are loosened. | Start | | | | | | | | | | | | | | | | | | | | | | | | |
| Check whether machine parts are missing (nuts/bolts). | Start | | | | | | | | | | | | | | | | | | | | | | | | |
| Clean every component of the machine. | Start/ with alarm | | | | | | | | | | | | | | | | | | | | | | | | |
| Clean needle and foot. | With alarm | | | | | | | | | | | | | | | | | | | | | | | | |
| Check oil leakages. | with alarm | | | | | | | | | | | | | | | | | | | | | | | | |
| Place a clean piece of paper under the foot. | End | | | | | | | | | | | | | | | | | | | | | | | | |
| Take the needle out and check whether it has bent/blunt. | End | | | | | | | | | | | | | | | | | | | | | | | | |
| Check whether there is abnormal noise generating in the machine. | Whole day | | | | | | | | | | | | | | | | | | | | | | | | |

Source : Based on the researcher 's observations and participants' insights

**Table 4 : Mechanic Checklist**

| Responsibility - Mechanic | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Step** | **Time** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Check oil level, leakages, and color. | Start | | | | | | | | | | | | | | | | | | | | | | | | |
| Pay attention about the oil paper. | Start | | | | | | | | | | | | | | | | | | | | | | | | |
| Check the compatibility of the thread and needle hole. | Start | | | | | | | | | | | | | | | | | | | | | | | | |
| Check the security devices. | Start | | | | | | | | | | | | | | | | | | | | | | | | |
| Check the cleanliness of the machine (air regulator, control board). | During the day | | | | | | | | | | | | | | | | | | | | | | | | |
| Pay attention about the service dates of the machine. | During the data | | | | | | | | | | | | | | | | | | | | | | | | |
| Check throat plate, looper, and Speed of the machine. | During the data | | | | | | | | | | | | | | | | | | | | | | | | |
| Pay attention about the abnormal noises of the machine. | Whole day | | | | | | | | | | | | | | | | | | | | | | | | |
| Check the timing of the machine. | Twice a week | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check the broken and worn off parts of the machine and replace them. | Once a week | | | | | | | | | | | | | | | | | | | | | | | | |
| Check the loosened components and repair them. | Once a week | | | | | | | | | | | | | | | | | | | | | | | | |

Source : Based on researcher's observations and participants' insights

during the shift, and once or twice a week. In order to complete the operator and mechanic checklists, it will take only 5 minutes and 4 minutes per day respectively, which is negligible as compared to the total available time per shift (480 minutes).

**6) Develop Overhaul Service Plan For Flatlock Sewing Machines :** The Overhaul service plan was also developed based on the data collected from Fishbone diagrams and types of abnormalities (Table 5). This overhaul service will be done in every 6 months and per one machine, it will take 116 minutes.

**Table 5: Overhaul Service Plan**

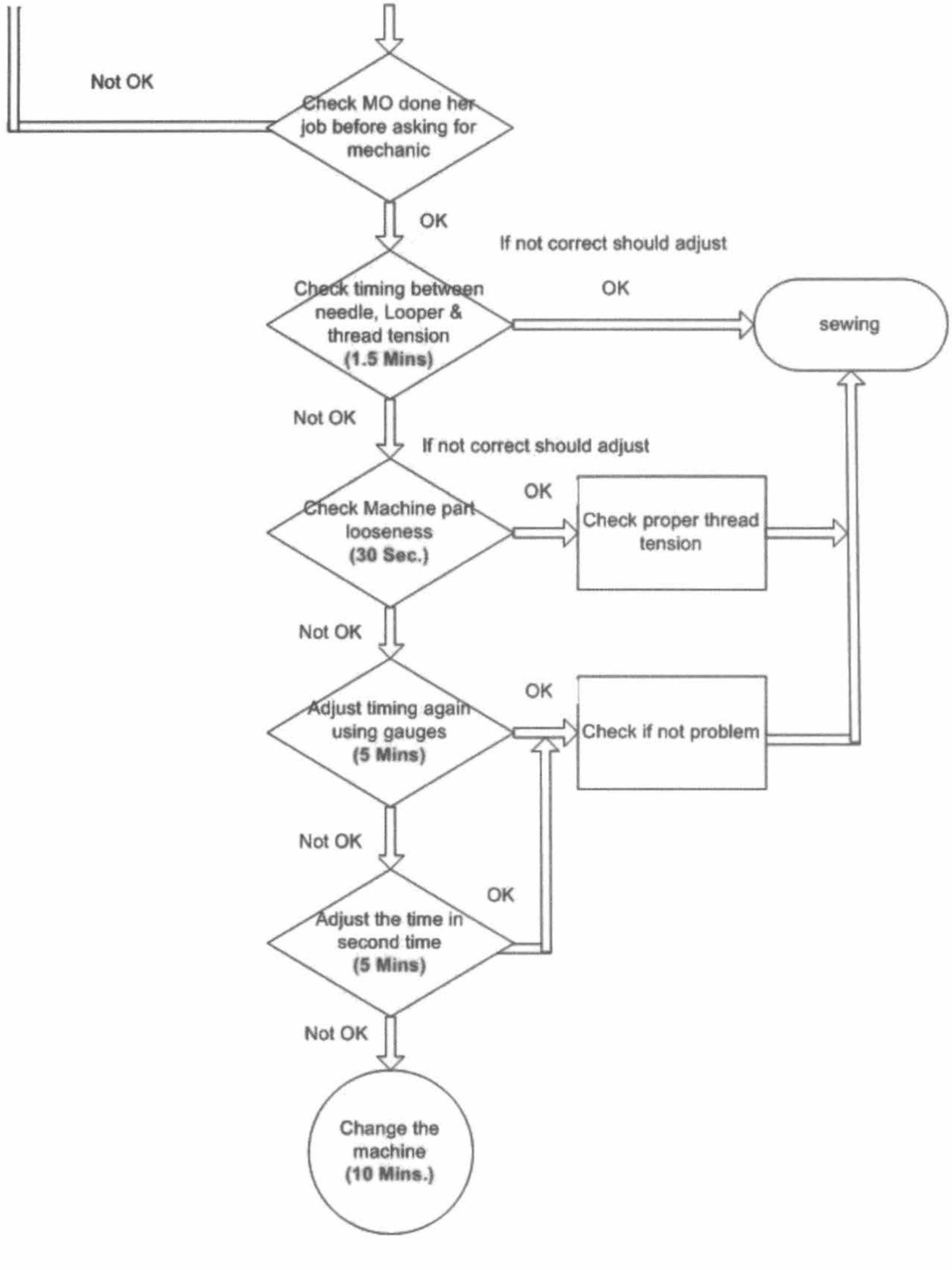
| Machine Part | Time (Minutes) | Action |
|---|---|---|
| Oil equipment | 25 | Replace |
| Oil level & cleanliness | 05 | Check |
| Oil filter | 10 | Replace |
| Pressure foot bar | 05 | Clean |
| Needle plate | 05 | Check |
| Feed dog | 04 | check |
| Pressure foot | 04 | Check |
| Looper | 04 | Check |
| Bottom thread tension control | 03 | Check |
| Thread stand | 03 | Check & Clean |
| Motor | 05 | Check |
| Take up spring | 03 | Check & Clean |
| Table up spring | 10 | Check & Clean |
| Safety equipments | 10 | Check |
| Control box | 05 | Clean |
| Trimmers & knife | 05 | Check |
| Sewing | 05 | Check |
| Timing | 05 | Check |
| **Total** | **116 (1hr. 56 mins.)** | |

Source : Based on researcher's observations and participants' insights

**7) Process For Attending A Breakdown :** The most frequent breakdown in Flatlock sewing machine is *"slipping"*. If there is a slip, a breakdown procedure was developed (Figure 5). Unlike in traditional machine breakdowns, here, the operator has to do some basic checkups before calling the mechanic. This saves the mechanic's time, and it is the responsibility of both - the operator and the mechanic to look after the machine. If the operator can manage the slip by herself, it will take only 30 seconds. The worst case (replace the machine) will take a maximum of 10 minutes of the production time.

**8) Train Operators / Mechanics :** This is the most important step in successfully implementing TPM in an organization. Lack of multi-talented employees is a problem for TPM, since sewing machine operators must know how to attend to basic machine repair work. Both parties must be well educated about this concept, and they must be aware that the total involvement is necessary in order to achieve the ultimate goals.

**Figure 5 : Process For Attending A Breakdown**




Source : Based on researcher's observations and participants' insights

**9) Prerequisite For TPM Machine :** After completing the afore-mentioned steps, a normal Flatlock sewing machine can be converted into a TPM Flatlock sewing machine by placing a TPM sticker on the top of the machine bed.

**1)** Initial cleaning done & abnormalities closed.

**2)** Operator check list done & started.

**3)** Mechanic check list done & started.

**4)** Overhaul/servicing done as per plan.

**5)**TPM sticker placed.

**6)** If there are 3 more breakdowns in a month, the TPM sticker is withdrawn, & the process 1 to 5 is repeated.

After the implementation of the checklists, the overhaul service plan and process for attending a breakdown, the following results were empirically derived in the selected production line :

❁ **To reduce breakdowns by 50% on Flatlock machines in a chosen line :** According to the Table 1, the following were found:

❁ Machine breakdowns = 9 = 0.81 BD/line/day (11 days from August – September in Line 9).

❁ Needle breakdowns = 102 = 9.27 NBD/line/day (11 days from August – September in Line 9).

❁ **Total breakdowns = 10.08 BD/line/day**

After completing the necessary steps and converting the machines into TPM, the following results were obtained :

❁ Machine breakdowns = 4 = 0.23 BD/line/day (17 days in November in Line 9).

❁ Needle breakdowns = 29 = 1.70 NBD/line/day (17 days in November in Line 9).

❁ **Total breakdowns = 1.93 BD/line/day**

It is clear that after following the TPM procedures, the number of needle breakdowns and machine breakdowns were remarkably reduced (82% reduction). This in turn reduces maintenance costs and machine downtime, thereby increasing the Overall Equipment Effectiveness (OEE).

❁ To reduce repair time of Flatlock machines to < 5 minutes in all cases, initially, it took 13 minutes to repair thread slipping breakdown (Table 6). After the process of attending a breakdown (Figure 5) was standardized, it took only 5 minutes for one machine timing setting. Also, for other breakdowns, the time taken was reduced to less than 5 minutes.

**Table 6: Time Taken To Repair The Major Types Of Breakdowns**

| Major breakdown | Steps taken at the repair | Time taken (minutes) |
|---|---|---|
| Thread slipping | Check Machine timing. | 5 |
| | Check whether machine part is damaged or not. | 5 |
| | Check whether the needle is blunt or bent. | 3 |
| Needle breakages | Check whether proper needles are being used. | 1 |
| | Check machine timing. | 5 |
| | Check whether operator sews correctly. | 1 |
| Uneven covering | Check machine setting. | 5 |
| | Check operator instructions. | 1 |

Source: Case company operational data

## CONCLUSION AND RECOMMENDATIONS

The above findings suggest that development of systematic, measurable, achievable, realistic and time-bound schedules to maintain machines in the production line would contribute to improving the efficiency and effectiveness of the production line. As an approach to practice this, TPM can be more appropriate in the apparel manufacturing organizations. In order to accomplish this task, the managers of apparel organizations can use TPM techniques systematically to reduce breakdowns in sewing machines.

As implementation of TPM concepts is still in the development stage (less than five years experience), the full benefit is not achieved yet. However, current situations suggest that the apparel industry can go forward with TPM. Therefore, organizations of similar type can use the research outcomes as a knowledge base to overcome the problematic areas. Findings of this research can be valuable to other organizations of Sri Lanka, which hope to implement TPM in the near future.

## LIMITATIONS OF THE STUDY AND SCOPE FOR FUTURE RESEARCH

The analysis reported in this paper has been carried out for Flatlock sewing machines in a single production line of a selected apparel organization. In future, researchers can develop more general maintenance schedules for different types of sewing machines, for several organizations across the apparel industry.

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