Total Productive Manufacturing (TPM)

Organizing for Maximum Equipment Productivity

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TPM Goals

• Increase overall equipment efficiency (OEE)
  – Example: Hewlett Packard fab increased average OEE by 33% over a 2-year period

• Increase consistency of equipment performance
  – Example: The HP fab reduced equipment fails by 95% over the same 2-year period
TPM is Simple and Hard

• **TPM is technically simple.** Its main feature is a major elevation of all staff’s knowledge, skill and role in improving equipment performance.

• **But 80-90% of TPM efforts in the USA failed**

• **And 50-60% of TPM efforts in Japan failed**
Nature of Equipment Failures

No. of defects or amount of lost production

Sporadic losses

Chronic loss

Time
Nature of Equipment Failures

- **Chronic loss** (e.g., one wafer breaks out of every 2,000 wafers processed, short-term jams, etc.)
  - “Normal” losses; typically, losses resulting from the design limits of the machine
- **Sporadic loss** (e.g., 12 wafers are ruined because a machine aborted, major failures, etc.)
  - Abnormal machine performance, typically requires trouble-shooting to restore machine to normal operation
TPM Strategy

• Conduct more frequent and thorough inspection and cleaning of machines to discover minor discrepancies before they become failures

• Enhance PMs to correct minor defects and prevent failures

• Re-design or modify equipment to reduce need for maintenance, to reduce difficulty to perform maintenance, and to reduce chronic losses
TPM Strategy (cont.)

• Elevate all employees’ knowledge, skill and role in improving equipment performance
  – Engineers, maintenance technicians, and especially production operators

• Measure overall equipment efficiency (OEE)

• Strive to reduce all productivity losses, including losses during utilization as well as down time losses and idle time losses
TPM Strategy - Maintenance

- “Autonomous maintenance” (production operators perform continuous inspection for minor defects as well as continuous cleaning, adjustment, and tidying up)
- Planned maintenance (technicians and engineers revise or enhance PMs to prevent sporadic failures)
- Maintenance prevention (engineers and equipment vendors re-design or modify equipment to reduce need for maintenance)
- Focused improvement teams working to reduce chronic losses
Typical Scenario in Many Companies

• Focused improvement teams formed that make some progress on chronic losses
• Achieving 100% compliance with scheduled PMs
• Breakdowns still occur at relatively high rate
• Breakdowns are most commonly of a new kind.
  “It’s always something.”
TPM Solution

• Most components provide some warning before they fail.
• Such warnings are typically observable with the human senses (most often visual).
• The key is to know how to inspect components, and to perform frequent and thorough inspections.
• Then one can replace breakdown maintenance by pre-emptive corrective maintenance on worn or mis-adjusted components.
TPM Solution (cont.)

• The starting point for TPM is implementing routine inspections (a.k.a “autonomous maintenance”) by production operators

  – Example: a stain reveals a small leak from the develop filter on a develop track; operators report this leak to technicians on a standard form

  – Example: operators tighten any loose lock nuts on needle valves (over 100) on each develop track

  – 1000s of minor defects reported and corrected
TPM Program

Year One

• Establish *deterioration limits* (standards) for all components

• Train operators using photographs (“One Point Lesson Sheets”) how to inspect for defects, adjust and clean
  – Example: Nine pages of photos of inspections to perform on an ion implanter (each inspection described as a One-Point Lesson)

• Forms created for operators to report defects they cannot correct
Standards for Deterioration

New -> Cosmetic -> Acceptable Defects

Wear & tear

Minor Defects & Major Defects

Technicians & Engineers define this limit for the operators

Acceptable Deterioration Limit

RCL 10/13
TPM Program (cont.)

Year One Results

• There exist standard limits for deterioration of every component maintained by the technicians.

• All operators are now inspectors; equipment inspections done every shift.

• Operators do cleaning & inspections in all safe areas, as well as make minor corrections (tighten lock nuts, re-bundle wire cabling, etc.).

• All equipment clean and free of known minor defects.
TPM Program (cont.)

• New paradigm: Restore every component to standard, even if machine is running OK

Year Two

• Failure prevention
  – Every sporadic loss triggers failure analysis to determine root cause, whereupon the inspection standards are revised to prevent recurrence

• Reduce chronic losses (productivity improvement)
  – Focused improvement teams of techs and operators
TPM Case Study

First-year results at HP fab:
- Failure rates down 40%
- Equipment availability raised to 85-90% (initially it went down)

TPM program cost at HP:
- **80% was people’s time**
  - Operators & techs train (2 hours per week)
  - Managers train and develop project leadership materials (2 hours per week)
  - 2 TPM project full-time staff
- **15% was outside training & consulting**
- **5% was increased spare parts** (initially)
Failure Modes of TPM Projects

• No change in job descriptions or criteria for performance evaluations
• Only some staff involved (really needs 100% of managers, operators, technicians, engineers)
• Implementation before learning and training
• TPM plans unilaterally done by some departments
• TPM program not adequately understood (needs an in-house leader who is knowledgeable)
TPM Project Organization

Only the manager can direct his/her employees to change their jobs.