Integrating SPC and TPM

1. Introduction

An important continuous improvement tool for manufacturing organizations is Total Productive Maintenance (TPM). Although both TPM and SPC are continuous improvement techniques it is normally not perceived that they have the same goals. What is commonly perceived is: The original goal of total productive management: "*Continuously improve all operational conditions, within a production system;* by stimulating the daily awareness of all employees*" (by Seiichi Nakajima, Japan, JIPM)*

An accurate and practical implementation of TPM, will increase productivity within the total organization, where :
(1) .. a clear business culture is designed to continuously improve the efficiency of the total production system
(2) .. a standardized and systematic approach is used, where all losses are prevented and/or known.
(3) .. all departments, influencing productivity, will be involved to move from a reactive- to a predictive mindset.
(4) .. a transparent multidisciplinary organization is reaching zero losses.
(5) .. steps are taken as a journey, not as a quick menu.

The Deming-method to plan, do, check , act and the underlying idea of people empowerment at the shop floor are present in both the TPM and SPC approach. For analyzing special causes of variation similar techniques are applied like FMEA, Pareto analysis, etc. The organizational structure to improve also shows great similarities between the two systems. The major difference is that TPM puts a lot of emphasis on quick change over (Single Minute Exchange of Dies (SMED)) and maintenance and SPC puts a lot of emphasis on improving critical quality characteristics as requested by customers. A second big differences seems to be the way data is gathered and reported. In TPM OEE data is reported and in SPC control charts and capability reports are made.
So in theory implementing a continuous improvement program which integrates both methods can be very rewarding for companies.
In this document we will show how SPC methods will help to improve OEE analysis and show how OEE analysis and reports are integrated in DataLyzer.

2. OEE ratios

To calculate the OEE of a machine or process we start with the total or plant operating time. This is the time the plant is actually open.

From this total time scheduled down time needs to be subtracted. Scheduled down time is for example breaks, planned maintenance, time with no orders.

The OEE is calculated against planned production time and consists of 3 ratios. The availability, the performance and the quality. So OEE = availability x performance x quality.

Availability

The availability is the ratio between operating time and total planned production time.

The 2 big losses in downtime loss are :

- change over and setup
- breakdowns of the machine

Performance

The performance ratio is the net operating time / operating time.

The 2 big losses in speed loss are:

- Small stops
- Reduced speed

The difference between small stops and a breakdown is the amount of time the machine is stopping. With a small stop the machine normally doesn't stop. Examples are a blocked cavity or a jam in packaging so one or 2 places stay empty. With small stops the production can be started almost instantly again.

Quality

The quality ratio is the productive time / net operating time.

The 2 big losses in quality loss are:

- Production rejects
- Startup rejects

OEE = Availability * Performance * Quality

To improve the net productive time the OEE ratios need to be improved or the scheduled down time needs to be decreased.

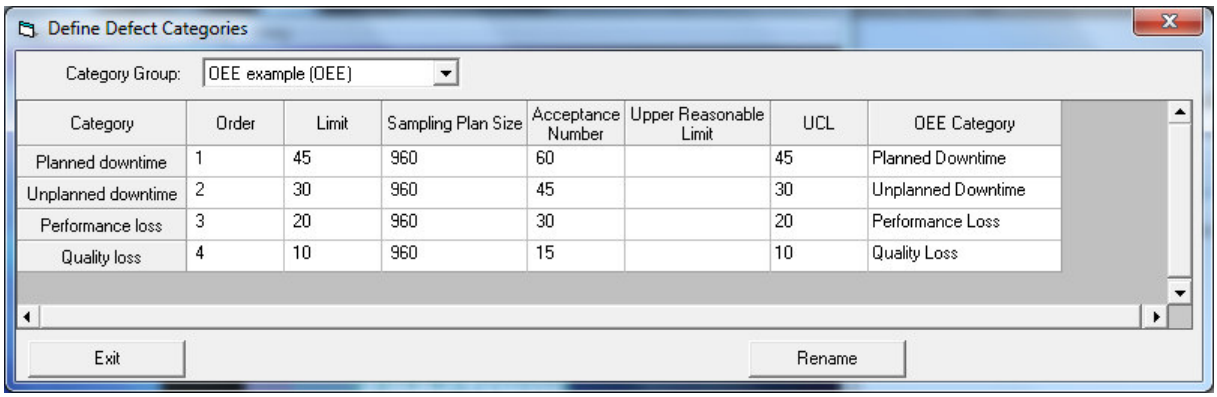
3. OEE integrated in DataLyzer Spectrum SPC module

The definition of the OEE ratios is pretty clear but measuring the different ratios is not always so easy. Measuring the total speed loss is more or less possible but it is not always easy to determine which part of the speed loss is caused by small stops and which part is caused by running with reduced speed. If all information is available in the PLC of the machine the information can be extracted and the different ratios can be calculated in detail. But even if we don't have a PLC connection we still can get a very good estimate of the OEE factors and get the right information to drive the improvement process.

In DataLyzer Spectrum the OEE registration can be setup easily by using categories, attribute control charts and optional parameters.

If you create an OEE category group DataLyzer will automatically create 4 categories for this group.

- Planned downtime
- Unplanned downtime
- Performance Loss
- Quality Loss



Category	Order	Limit	Sampling Plan Size	Acceptance Number	Upper Reasonable Limit	UCL	OEE Category
Planned downtime	1	45	960	60		45	Planned Downtime
Unplanned downtime	2	30	960	45		30	Unplanned Downtime
Performance loss	3	20	960	30		20	Performance Loss
Quality loss	4	10	960	15		10	Quality Loss

Figure 1: Categories for OEE calculation

We can set (statistical) limits per category and the last 3 categories are used for the OEE calculation. Limits can be set per shift or can be set for aggregated time periods.

Data input for OEE analysis and reporting can be done automatically by extracting data from external sources or manually at the end of a shift.

In figure 2 the data entry screen is given in case data entry is done manually. Relevant data will be entered or calculated based on optional parameter values entered.

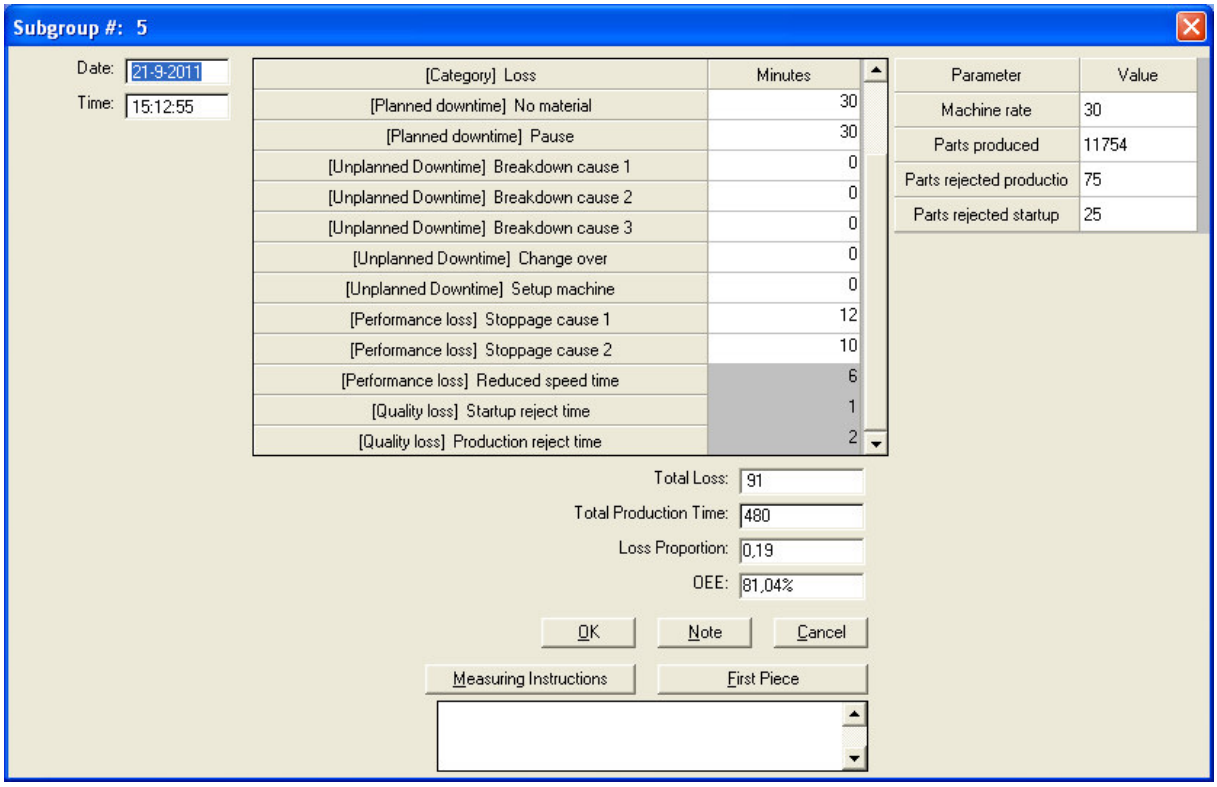


Figure 2: Input screen OEE data

4. OEE Improvement cycle

The big advantage of showing OEE results in an attribute chart is that you can perform statistical analysis on the losses, get alarms on out of control values and the improvement cycle which is in place for SPC can be used for productivity improvement as well.

Figure 3 shows a typical OEE attribute chart.

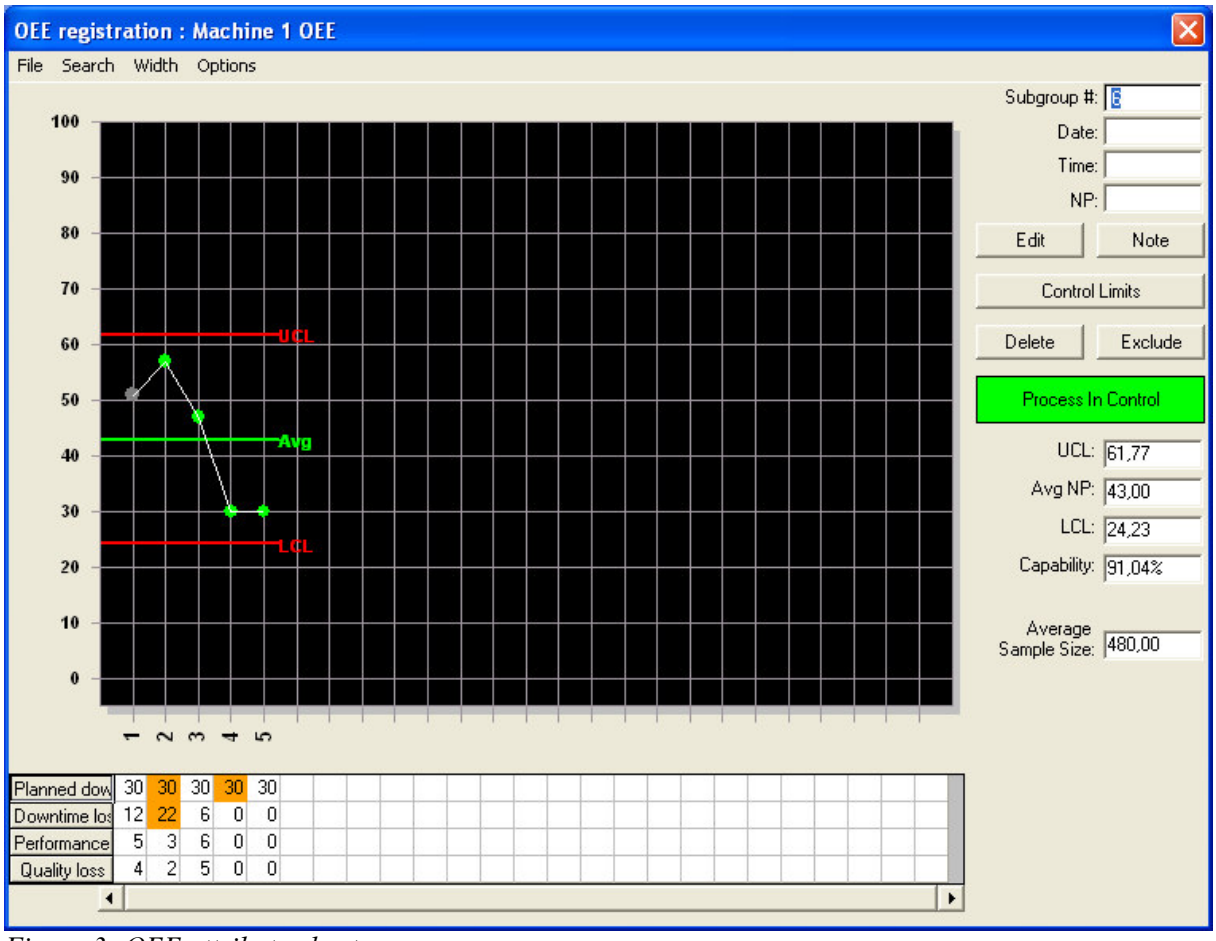


Figure 3: OEE attribute chart

If limits are exceeded the corrective action procedure is automatically activated.
The status can indicate an excessive loss for that shift or for an aggregated time period depending how the system is setup.

If you want to analyze a specific loss category you drill down by clicking on the specific category. For example if you click on downtime loss the chart looks like figure 4.

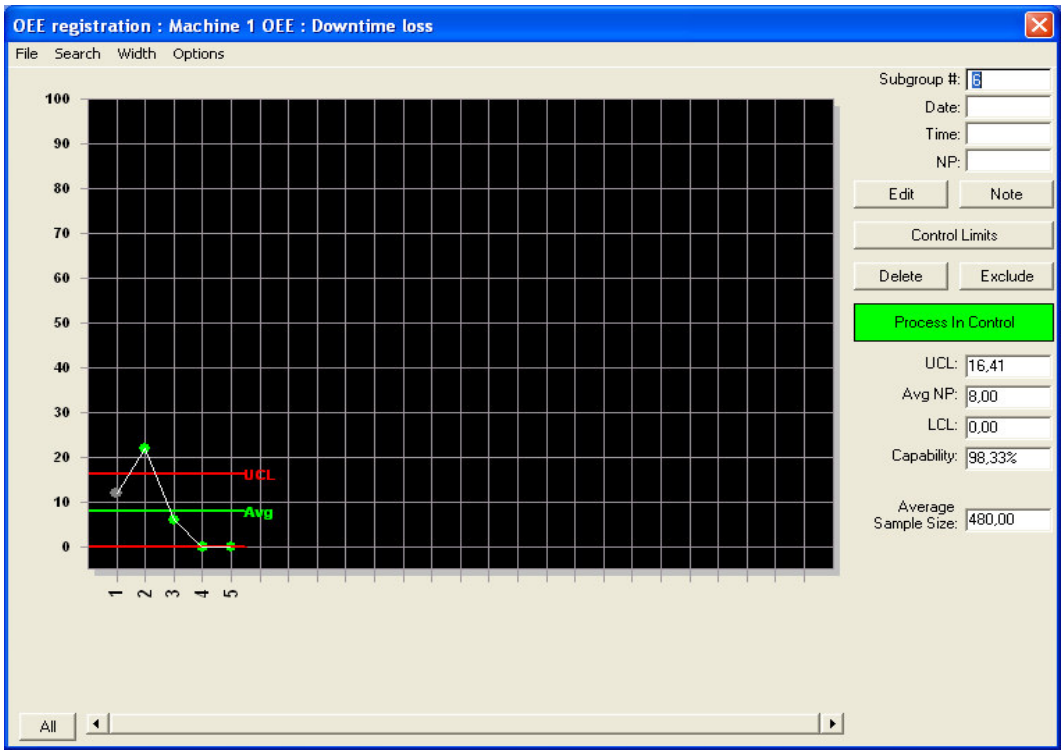
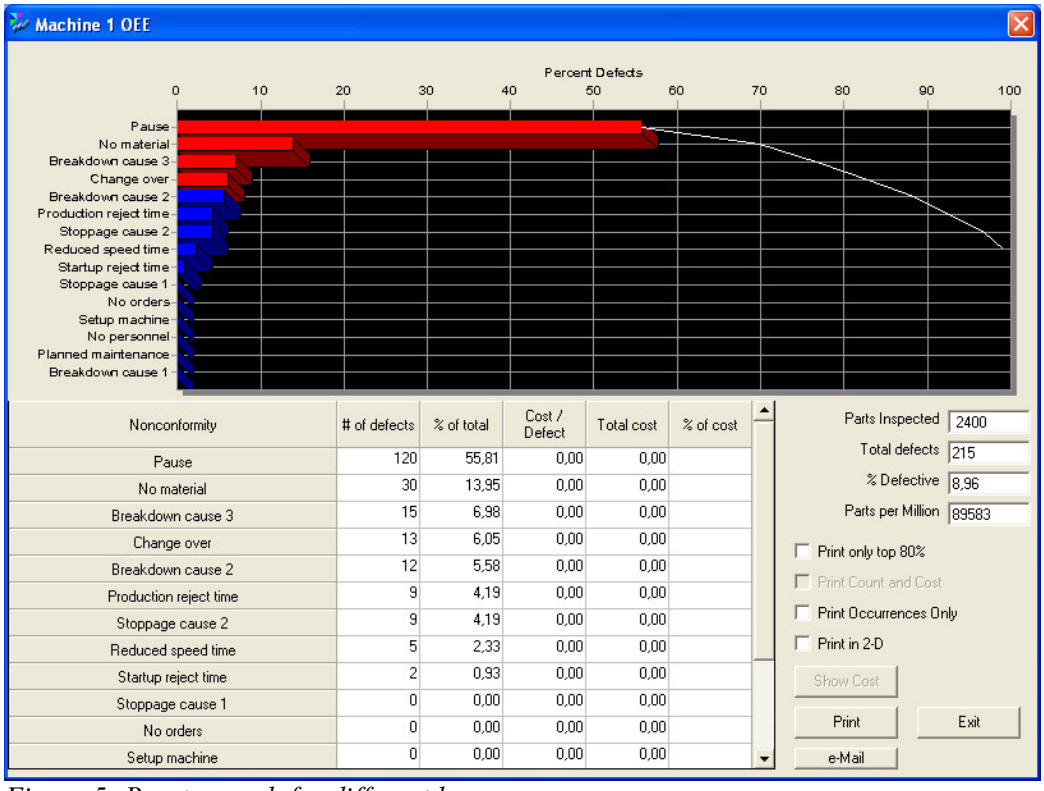


Figure 4: Attribute control chart for the downtime loss category

The chart shows the control limits and clearly indicate if a specific loss is out of control.

For the individual losses Pareto analysis can be made for every time period like shown in figure 5.



Nonconformity	# of defects	% of total	Cost / Defect	Total cost	% of cost
Pause	120	55,81	0,00	0,00	
No material	30	13,95	0,00	0,00	
Breakdown cause 3	15	6,98	0,00	0,00	
Change over	13	6,05	0,00	0,00	
Breakdown cause 2	12	5,58	0,00	0,00	
Production reject time	9	4,19	0,00	0,00	
Stoppage cause 2	9	4,19	0,00	0,00	
Reduced speed time	5	2,33	0,00	0,00	
Startup reject time	2	0,93	0,00	0,00	
Stoppage cause 1	0	0,00	0,00	0,00	
No orders	0	0,00	0,00	0,00	
Setup machine	0	0,00	0,00	0,00	

Figure 5: Pareto graph for different losses

5. Improvement targets and reports

To get results from continuous improvement – no matter if it is SPC or TPM – the management needs to set targets and provide the means to realize these improvements. The OEE data should be aggregated on a daily, weekly or monthly basis making it possible for management to compare results against targets. Figure 7 shows a report aggregated per day.

OEE History

Report: OEE **Summary:** Day **Dates:** 19-09-11 to 25-09-11

Characteristic: Machine 1 OEE

Category		1	2	3	4	5	6	7
	Date	19-09-11	20-09-11	21-09-11	22-09-11	23-09-11	24-09-11	25-09-11
	Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	Production time	**960**	**480**	**960**	**960**	**960**	**960**	**480**
Planned downtime	Planned maintenance	0	0	0	0	35	0	0
	No orders	0	0	0	0	0	0	0
	No personnel	0	0	0	0	0	0	0
	No material	0	0	30	0	0	0	0
	Pause	60	30	60	60	60	60	30
	Total Planned downtime	**60**	**30**	**90**	**60**	**95**	**60**	**30**
	Planned production time	**900**	**450**	**870**	**900**	**865**	**900**	**450**
Unplanned Downtime	Breakdown cause 1	0	0	0	14	0	0	0
	Breakdown cause 2	12	0	0	17	0	0	0
	Breakdown cause 3	15	0	0	12	7	37	75
	Change over	7	6	0	15	10	0	0
	Setup machine	0	0	0	7	8	40	0
	Total Unplanned Downtime	**34**	**6**	**0**	**65**	**25**	**77**	**75**
	Availability	**96.22%**	**98.67%**	**100.00%**	**92.78%**	**97.11%**	**91.44%**	**83.33%**
Performance loss	Stoppage cause 1	0	0	12	5	0	0	10
	Stoppage cause 2	3	6	10	19	14	0	0
	Reduced speed time	5	0	6	12	12	6	0
	Total Performance loss	**8**	**6**	**28**	**36**	**26**	**6**	**10**
	Performance	**99.08%**	**98.65%**	**96.78%**	**95.69%**	**96.90%**	**99.27%**	**97.33%**
Quality loss	Startup reject time	2	0	1	2	0	0	1
	Production reject time	4	5	2	3	1	2	1
	Total Quality loss	**6**	**5**	**3**	**5**	**1**	**2**	**2**
	Quality	**99.31%**	**98.87%**	**99.66%**	**99.40%**	**99.88%**	**99.76%**	**99.47%**
	OEE	**94.67%**	**96.22%**	**96.44%**	**88.22%**	**93.99%**	**90.56%**	**80.67%**
	Percentage loss	11.25%	9.79%	12.60%	17.29%	15.31%	15.10%	24.38%

Figure 6: OEE history report sorted per day

6. Advantages integrating SPC and OEE

In this whitepaper we have shown how you can use DataLyzer Spectrum as well for SPC as for TPM. Integrating the two approaches in one improvement approach and using one software solution has advantages:

- Productivity and quality will be equally important and the company will truly benefit if both are improved.
- The methodology for continuous improvement will be accepted quicker if both methods are integrated and supported by one approach and one software system.
- When companies use both methods time required for training, system support and system maintenance is reduced.
- Software investments are strongly reduced by using one integrated system

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