OEE 105

How does PlantWeb improve OEE?

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Overview

Now that you've seen how availability, productivity, and quality each affect profitability, let's look at how they combine to measure Overall Equipment Effectiveness — and how using Emerson's PlantWeb architecture can improve results.

To do that, this course uses the case of an example plant. We'll evaluate the plant's performance and PlantWeb's impact on each of three factors, as well as the cumulative effect on OEE.

Hint: As you go through the topics in this course, watch for specific ways that PlantWeb helps improve availability, productivity, and quality.

Plant background

The example petrochemical plant has a low-density, high-pressure tubular polyethylene plant, a vinyl chloride monomer plant, and an emulsion and a suspension PVC plant, along with a fuel and steam system.

Ethylene and chlorine feedstocks, mainly from local sources, total 670,000 tons per year. Feed costs are $254.5 million, or $379/ton.

Yearly production is 650,000 tons, valued at $540 million. Gross operating margin is $245 million or 45% of revenue.

The plant's management has several specific concerns, including

- Margins are eroding as new capacity — with newer process technology — comes onstream overseas.
- Production of higher-quality product that will open up more markets is difficult because of high variability and off-spec production.
- Downtime is affecting profitability: Scheduled downtime averages 9 days per year, and unscheduled outages average 11 days per year.
- Production loss due to trips and variable constraints averages 60,000 tons of feed per year.
- During extremely hot weather, the steam header pressure letdown valve constrains operation of the feed compressor turbines in the polyethylene unit. The operators don't like to run the valve near its limit, because if it does go off control most of the units will be affected and trips may occur.
- Production is limited by the amount of stripping steam that can be forced into the continuous VCM recovery stripper of the emulsion plant. If steam flow rate is set higher than 95%, the controller becomes unstable. To make their life easier, the operators leave this at an average of 91%.

PlantWeb architecture

The benefits of using PlantWeb architecture in the example plant reflect incremental improvements from using PlantWeb instead of a traditional mixture of DCS/PLC and direct-wired instrumentation.

The example calculations assume that PlantWeb is used for all critical instruments (those that on failure will immediately cause the process to start moving away from the desired operating point), as well as all non-critical measurements and modulating valves.

The PlantWeb architecture includes DeltaV and Ovation process automation systems and AMS Suite application software for the whole plant, along with Emerson field devices with FOUNDATION fieldbus communications or HART communications.

Availability

Without PlantWeb, availability is calculated as follows:

Possible production time	=	(365 - 9) days
	=	356 days
Actual production time	=	(365 -9 - 11) days
	=	345 days
Availability	=	$\frac{\text{Actual production time}}{\text{Possible production time}}$
	=	345 / 356
	=	**97%**

The 3% lost availability represents expensive product going to flare or being downgraded to scrap.

Improving availability with PlantWeb

PlantWeb's fault detection and monitoring capabilities can not only reduce the number of plant shutdowns, but also provide valuable data that can be utilized to provide pro-active maintenance and scheduling.

PlantWeb can help improve availability through:

- Use of intelligent field devices with diagnostics integrated with AMS Suite: Intelligent Device Manager to minimize unnecessary maintenance. More information on true plant status also leads to faster troubleshooting.
- A single user interface for HART, analog, and FOUNDATION fieldbus instruments also makes troubleshooting easier
- Improved instrument reliability.

These same features and tools can also reduce the turn around time during planned shutdowns. When applied to the example plant, the downtime can be reduced by 15%.

Downtime reduction with Plantweb

Unscheduled shutdowns	=	15% of 11 days

	=	1.65 days reduction in forced outages
Scheduled shutdowns	=	15% of 9 days
	=	1.35 days
Downtime reduction	=	1.65 + 1.35 days
	=	3 days

Making the new downtime

Unscheduled shutdowns	=	11 days - 1.65 days
	=	9.35 days
Scheduled shutdowns	=	9 days - 1.35 days
	=	7.65 days
Total downtime	=	9.35 + 7.65 days
	=	7 days

And the new availability level

Availability with PlantWeb	=	(365 – 17) / (365 - 7.65)
	=	97.4%

The plant's profit is

$245,000,000 /356 days	=	$688,202 per day

which means the incremental profit from increased availability is

$688,202 X 3 days	=	**$2.065 million**

Productivity

Without PlantWeb, the plant's productivity on an annual basis is 90.8%:

$$\% \text{ Productivity} = \frac{\text{actual production}}{\text{optimum target production}}$$

$$= \frac{(650{,}000 \text{ tons} - 60{,}000 \text{ tons})}{650{,}000 \text{ tons}}$$

$$= 590{,}000 / 650{,}000$$

$$= 90.8\%$$

Better results with PlantWeb.

PlantWeb can help the example plant improve capacity utilization, for total benefit of $3,365,000/year.

The operator will attempt to keep the plant at the presently limiting set of constraints. It's inevitable that the operator will be cautious, and there will always be a differential between the actual operation and optimum productivity.

PlantWeb can help the operator move closer to that optimum. Device diagnostics and AMS Device Manager software help by accurately reporting the actual valve position, by ensuring that the correctly-sized valve is in use, by diagnosing hysteresis and other valve problems, and by signaling if the loop is off control. These all increase the operator's confidence in the correct operation of the control valves.

With less process variability, improved accuracy, and more standard and reliable controls, the operator will also feel confident moving closer to other plant constraints.

For example, the steam header letdown valve constraint affects most of the units in the example plant. The letdown valve is generally put at a conservative limit, affecting throughput of plants where compressors are the bottleneck during hot weather, as well as steam feed to process heat exchangers. With PlantWeb the letdown valves are assumed to move from their present average equivalent 85% throughput to 87.5% while still giving operators steady control.

Other constraints that are relieved by PlantWeb concern the VCM monomer feed transfer valves, the level on the reflux condensers in the suspension plant reactor, the temperature measuring devices that the operator uses to control the reactor throughput and melt index in the high pressure polyethylene reactor, and the ethylene compressor discharge pressure.

Advanced control technology typically permits a 2% increase in the feed rate to units that are required to operate at their maximum capacity. In this example, the steam letdown valve limit is used to calculate the improved plant throughput using PlantWeb. Calculations for the other process constraints are similar.

The steam letdown average is increased by 1%, from 85% to 86%. If the operational range of the valve is 65% (30% to 95% valve opening), the 1% increase in valve opening represents a 1.5% increase in steam flow. Assuming the incremental increase in steam flow is equal to the incremental increase in plant production, the improved profit is calculated as follows:

Plant production level
(after reduction in downtime) = $\dfrac{(590{,}000 \text{ tons/yr} * 348 \text{ days/year})}{345 \text{ days/year}}$

= 595,130 tons/year

Gross margin = $245,000,000 /year

650,000 tons / year

= $377 / ton

Increased profit = .015 increase * 595,130 tons/yr *$377/ ton

= $3,365,000 / year

And the new productivity calculation is

% Productivity = Actual production / optimum target production

$$= \frac{(595{,}130 \text{ tons} * 1.015 \text{ capacity})}{650{,}000 \text{ tons}}$$

= 92.9%

Quality

The plant feed is 670,000 tons/year, and production (before the reductions in downtime) was 650,000 tons/year. The difference — 20,000 tons/year — was off-spec product.

Before using PlantWeb architecture, therefore, the example plant's quality calculation was:

$$\% \text{ Quality} = \frac{\text{product produced - (scrap \& rework)}}{\text{product produced}}$$

$$= \frac{670{,}000 - 20{,}000 \text{ tons/year}}{670{,}000 \text{ tons/year}}$$

= 97%

Improving quality with PlantWeb.

The multivariable, model predictive control (MPC) technology used by DeltaV and Ovation automatically accounts for process interactions and difficult process dynamics. For example, DeltaV Predict easily handles excessive deadtime, long time constants, inverse responses, and loop interactions. Through these advanced control techniques, the variability in key process variables can be dramatically reduced.

With improved measurement and control using PlantWeb architecture, 5% of the off-spec material can be converted to prime product.

Increased prime product = 5% * 20,000 tons/year
= 1000 tons/year

At $377 / ton gross profit margin,

Increased profit	=	1000 tons/year * $377 / ton
	=	$377,000 /year

And the new quality rate is

% Quality	=	(650,000 + 1,000) / 670,000
	=	97.2%

OEE calculations

Without PlantWeb:

OEE	=	Availability* Productivity* Quality
	=	97% x 90.8% x 97%
	=	85.4%

With PlantWeb:

OEE	=	97.4% x 92.9% x 97.2%
	=	88%

As the example shows, however, OEE is simply a metric. It tells you if you're making progress in improving your plant's profitability. The real value comes from the savings and increased profit opportunities that PlantWeb offers by improving availability, productivity, and quality.