Optimising shutdown intervals

For many industries, planned shutdowns or outages are a fact of life. Mandatory in some cases, opportune in others, they still cause significant headaches in costs, disruption and 'lost opportunity' or system availability terms. Then there's the period following a shutdown, which often exhibits system instability or recommissioning problems. Alex Thomson, Principal Consultant, The Woodhouse Partnership Ltd (TWPL), looks at these issues.

A lot of good work has been done in the field of shutdown planning and execution, achieving great reductions in costs and shutdown durations. However, the core question of when (or how often) we should shutdown in the first place often gets overlooked, or people assume it's out of their hands. Shutdown cycles become established with no real strategic thought process beyond the next single occasion or planning cycle. A self-perpetuating habit often develops as a result.

It was to challenge this habit, and determine the real need, that SABIC Innovative Plastics (SABIC IP) decided to review the options in a more systematic way across its four production sites in Europe and the USA. Each has an annual or bi-annual shutdown for inspections, maintenance and engineering project work.

In April 2008, the SABIC IP management team decided to partner with TWPL in carrying out a Shutdown Optimisation Project across the four sites, starting at Bergen op Zoom in the Netherlands.

Shutdown interval optimisation

The polycarbonate manufacturing process at Bergen op Zoom is summarised in Figure 1, with the primary production units circled in red.

The analysis process introduced by TWPL involved five steps:

1. Identifying critical timing-sensitive, shutdown-dependent tasks

2. Cost/risk evaluation of optimal individual timing for these tasks

3. Evaluation of optimal bundling, alignments and opportunity work

4. Identification of shutdown cycle-constraining tasks and the actions (eg plant modifications) required to eliminate the need for them

5. Re-optimisation of work bundles and total shutdown strategy.

The TWPL Criticality Method was used to assess the impact and potential urgency of tasks that appeared to require a plant shutdown. A series of further filters were then applied, using multidisciplinary teams to challenge these requirements from different angles

The results of the assessment showed that from a total of 24,260 inspection and maintenance tasks, 7,875 were initially regarded as 'shutdown dependent'. Yet, following a four-step challenge process, only 86 were found to be truly shutdown dependent and timing sensitive – demonstrating the extent of the shutdown cycle self-perpetuating habit that had become established.

Analysis of individual tasks

The next step was to determine the cost/risk optimal interval for each critical individual task. This must be done carefully to consider all the business drivers, regulatory constraints, failure modes and risk patterns, particularly with incomplete data and uncertain assumptions. APT software tools modelled the risk assumptions, calculated total business impact and performed extensive 'what if?' and sensitivity studies.

Great care was also taken by the study facilitators to extract and quantify tacit knowledge from the multidisciplinary teams. Range-estimating techniques were used to capture the limits of possibility for any uncertain data. Where this uncertainty was found to affect the optimum task timing significantly, the financial implications of such uncertainty were calculated, providing the business case for efforts to search for more robust and accurate data or additional expertise.

This individual task modelling revealed many to have optimal intervals of four years or more; much more infrequent than current practices.

Figure 1: Polycarbonate production process

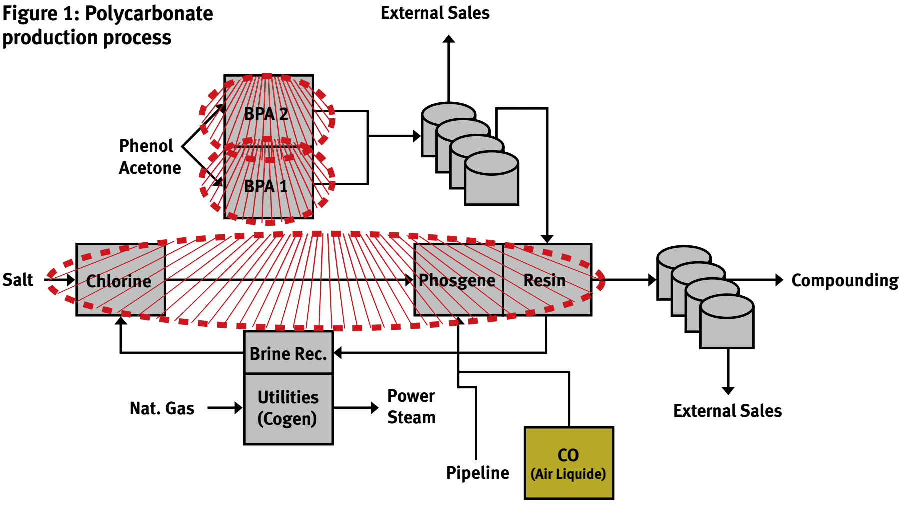


Table 1: Filtering and screening results

	Initial Task List (all activities)	Tasks remaining after initial screening	Tasks remaining after equipment filter	Tasks after interval filter	Tasks needing cost/risk modeling
CHLORINE	5392	2135	890	48	19
PHOSGENE	1616	698	157	59	2
RESIN	8301	2066	863	139	8
BPA1	4475	1826	127	2	2
BPA2	4476	1150	390	72	55
Total	24260	7875	2427	320	86

First published in *Assets*, the magazine for Members of the IAM. November 2009

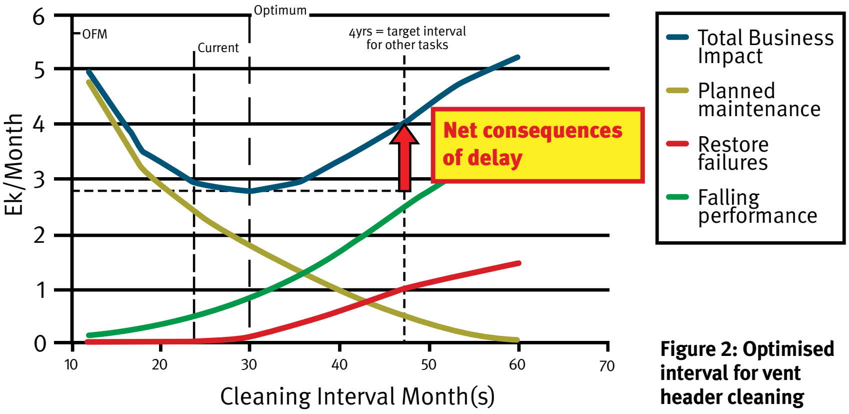


Figure 2: Optimised interval for vent header cleaning

Some tasks, on the other hand, showed optimal intervals of just one or two years, representing ‘bottlenecks’ to the achievement of longer shutdown intervals.

A typical shutdown-dependent task is the internal cleaning of the Phenol vent header pipe. This task is required because fouling of the pipe reduces process efficiency. The task was analysed using the APT-MAINTENANCE module, which revealed it to be one of the ‘bottleneck’ activities that should not be set at longer intervals (see Figure 2).

Figure 2 shows the contributing factors in the ‘most likely’ scenario. In this case, and in all reasonable variations in assumptions, the optimum interval is around 24-30 months. Delaying the cleaning to 48 months, in order to align with other long-cycle activities, would introduce additional total business costs of c.€1,200/month or €14,400/year.

Optimising bundles of tasks

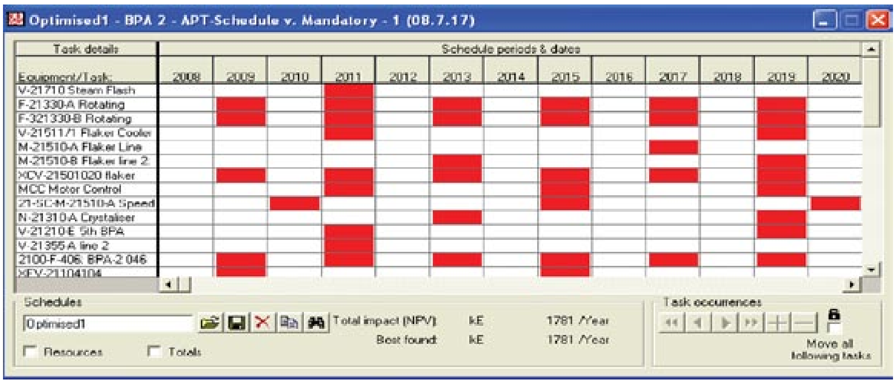
Having evaluated the personal optimum and cost/risk implications of sub-optimal timing for each critical task, the next step was to assess the best way of combining tasks to share downtime or other bundling advantages. This was an extremely complex step, as it must consider the cost/risk impact of delaying a task or performing it prematurely, to align with other jobs. There are also possibilities for doing one task every second, third or other multiple of the interval for others. In fact, there are about 10^{27} possible ways of coordinating just 10 tasks on a 12 to 18-month horizon – a planner’s nightmare!

APT-SCHEDULE software is designed to address this problem, using a self-learning ‘genetic algorithm’ to discover the best combined work programme, minimising total costs, risks, production downtime and other business impact. There were 32 critical, timing-sensitive tasks carried forward to this ‘optimal bundling and scheduling’ stage.

The results showed that there were a number of tasks which were still required and justified a frequent (biannual) shutdown and the remainder mapped onto every fourth, sixth, eighth or twelfth year. The next step was therefore to de-bottleneck or remove the need for the high-frequency shutdown-dependent tasks. A total of 15 de-bottlenecking actions were identified for the Bergen op Zoom site; in most cases representing very small investments. In only one case was significant investment required – to install a bypass that allowed online maintenance of the existing equipment. The payback period for this project, like other de-bottlenecking actions, was determined to be less than 12 months.

Having identified the de-bottlenecking tasks and removed them from the task list, the APT-SCHEDULE analysis was re-run. The results of this, for the BPA2 unit, are part shown in Figure 4.

It revealed that the optimum shutdown interval is now four years. The APT-SCHEDULE outputs included a full NPV calculation of the costs, risks and production impact of this programme (and any alternative, such as the effect of an unplanned shutdown). So the full impact of the changes was directly quantifiable – and represented seven-figure annualised net benefits. With the sensitivity testing already built in, and full ‘drill-down’ clarity about which activities contribute how much to the urgency and justification for each shutdown, SABIC senior management committed to the revised plan immediately, and all de-bottlenecking actions were approved and under way within two months of the study. The Bergen op Zoom site is changing to the new four-year shutdown cycle as soon as these actions are completed, and the process is being rolled out to other SABIC IP sites with the support of TWPL facilitators.


Optimised1 - BPA 2 - APT-Schedule v. Mandatory - 1 (08.7.17)

Task details	Schedule periods & dates												
Equipment/Task:	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
V-21710 Steam Flash				🟥									
F-21330-A Rotating		🟥		🟥		🟥		🟥		🟥		🟥	
F-321330-B Rotating		🟥		🟥		🟥		🟥		🟥		🟥	
V-21511/1 Flaker Cooler				🟥								🟥	
M-21510-A Flaker Line										🟥			
M-21510-B Flaker line 2						🟥						🟥	
XCV-21501020 flaker		🟥		🟥		🟥		🟥		🟥		🟥	
MCC Motor Control				🟥				🟥				🟥	
21-SC-M-21510-A Speed			🟥					🟥					🟥
N-21310-A Crystaliser						🟥						🟥	
V-21210-E 5th BPA				🟥								🟥	
V-21355-A line 2				🟥									
2100-F-406: BPA-2 046		🟥		🟥		🟥		🟥		🟥		🟥	
XFV-21104104		🟥						🟥					

Schedules
Optimised1
Total impact (NPV) kE 1781 /Year
Best found kE 1781 /Year
☐ Resources
☐ Totals
Task occurrences
Move all following tasks

Figure 3: APT-SCHEDULE initial results (partial list for BPA2 plant unit)

Task details	Schedule periods & dates												
Equipment/Task:	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
M-21510-A Flaker Line 1: BPA2-014-A-E								🟥					
M-21510-B Flaker line 2: BPA2-015-A-E				🟥								🟥	
MCC Motor Control Center: BPA2-054-A-W preventive maint				🟥				🟥				🟥	
N-21310-A Crystaliser pump: BPA2 051 A-W N-21310 pump overhaul												🟥	
N-21310-B: BPA2 082 A-W N-21310 pump overhaul													
N-21310-C: BPA2 083 A-W N-21310 pump overhaul													
N-21310-D: BPA2 084 A-W N-21310 pump overhaul													
XCV-21501013 N2 purge to flaker: BPA2-086-A E overhaul				🟥				🟥				🟥	
XCV-21501020 flaker by-pass valve: BPA2-052-A E overhaul				🟥				🟥				🟥	
XCV-21501025 N2 purge to flaker: BPA2-085-A E overhaul				🟥				🟥				🟥	
2100F-406: BPA2-064-A M - inspection				🟥				🟥				🟥	
F-21514-A Flaker Vent Filter: BPA2 025-A M Internal inspection				🟥				🟥				🟥	
F-21514-B Flaker Vent Filter: BPA2 026-A M Internal inspection				🟥				🟥				🟥	
H-21210-A: BPA 2 077-A-M Internal inspection				🟥									
H-21210-B: BPA 2 078-A-M Internal inspection				🟥								🟥	
H-21355-A Line 1 Sealant cooler: BPA2-001-A M Internal Inspection				🟥				🟥				🟥	
H-21355-B Line 2 Sealant Cooler: BPA2-002-A M Internal Inspection				🟥				🟥				🟥	

Figure 4: De-bottlenecked, re-optimised schedule