Optimizing shutdown intervals yields significant savings

Introduction

For many industries planned shutdowns or outages are a fact of life. Whilst such shutdowns are often essential to ensure system safety and/or regulatory compliance, from an operational perspective they are undesirable because they cause loss of system availability, incur significant planning, coordination control overheads and often introduce system instabilities and recommissioning problems during the start-up phase.

A lot of good work has been done in the field of shutdown planning and execution, achieving reductions in direct costs and shutdown durations. However, the core challenge facing Asset Managers is in answering the question:

When (or how often) should I shutdown in the first place?

This is not an easy question to answer. The key role of any Asset Manager is to *optimise* the *costs, risks and performance* of owning and operating the assets over their *whole life cycle* – this includes minimising the 'Total Business Impact'[1] all expenditures, risks and performance 'lost (performance shortfall, quality losses, downtime losses etc). With big money at stake, many (sometimes conflicting) regulatory obligations and uncertain risks, such goals are difficult to identify, let alone demonstrate in their attainment. Shutdown timing or intervals, in particular, have often become established with no real strategic thought process beyond the next single occasion or a cyclic planning assumption. A self-perpetuating cycle often develops as a result:

"We have a shutdown every (x) year(s) because we have so much work to do…"

AND/OR

"We have to use the opportunity of the (annual) shutdowns to do as much work as possible while we can….".

Shutdown Interval Optimisation at SABIC Innovative Plastics

SABIC Innovative Plastics (SABIC IP) is part of the Saudi Basic Industries Corporation, and has four polycarbonate production facilities in Europe and the USA. Each site had an annual or bi-annual shutdown for inspections, maintenance and engineering projects.

In April 2008, following a review of possible processes and available tools, the management team decided to partner with The Woodhouse Partnership Ltd (TWPL) in carrying out a Shutdown Optimisation Project across the four sites, with the first site being Bergen op Zoom, The Netherlands. The project received senior management support with a goal of significant cost reduction and performance improvement.

Shutdown Interval Optimisation in Bergen op Zoom

The polycarbonate manufacturing facility at Bergen op Zoom is summarised in Figure 1, with the primary production units that were the subject of the study circled in red:

[1] See www.MACROproject.org and optimisation guidance in PAS 55-2:2008

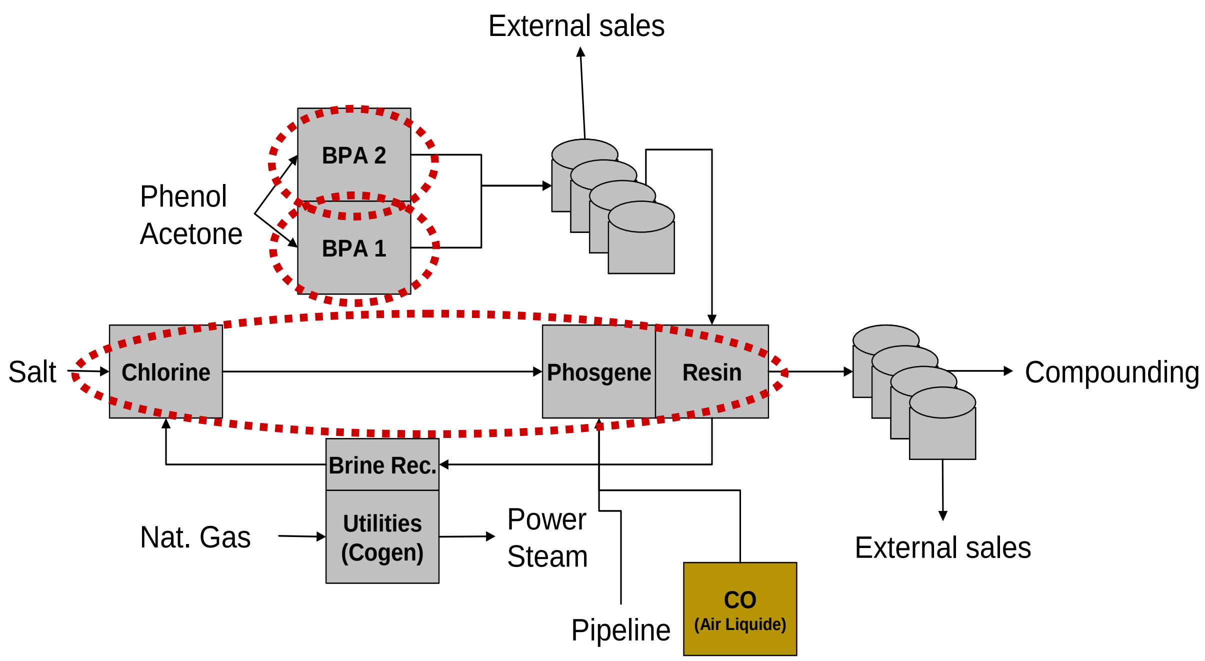

Figure. 1 Polycarbonate Process Flow: BoZ

Project Methodology

The first issue addressed was to define "what constitutes a shutdown?" For this project a shutdown was defined as:

"A planned event (to execute a pre-defined asset maintenance, inspection or engineering workscope) that reduces plant output by 50% production for a period of at least 24 hrs (or equivalent)."

This definition was essential in order to filter out activities that do not really need a major outage.

The TWPL Criticality Method was then calibrated to assess the impact and potential urgency of each task that appeared to require a shutdown of the plant. These were then challenged and filtered down to a list of the truly shutdown-dependent activities, which were first evaluated individually, and then collectively, using the leading edge APT software tools for optimal timing and 'bundling'. This methodology is shown in Figure 2 below:

The first step in the process is to select, from the entire workload, only those tasks which truly drive the requirement to shut down the plant. This was achieved through a series of screening and filtering processes. The selective filters ranged from a simple rule-based screening to assessment and challenge by multidisciplinary teams. The results of the screening and filtering process are shown in Table 1.

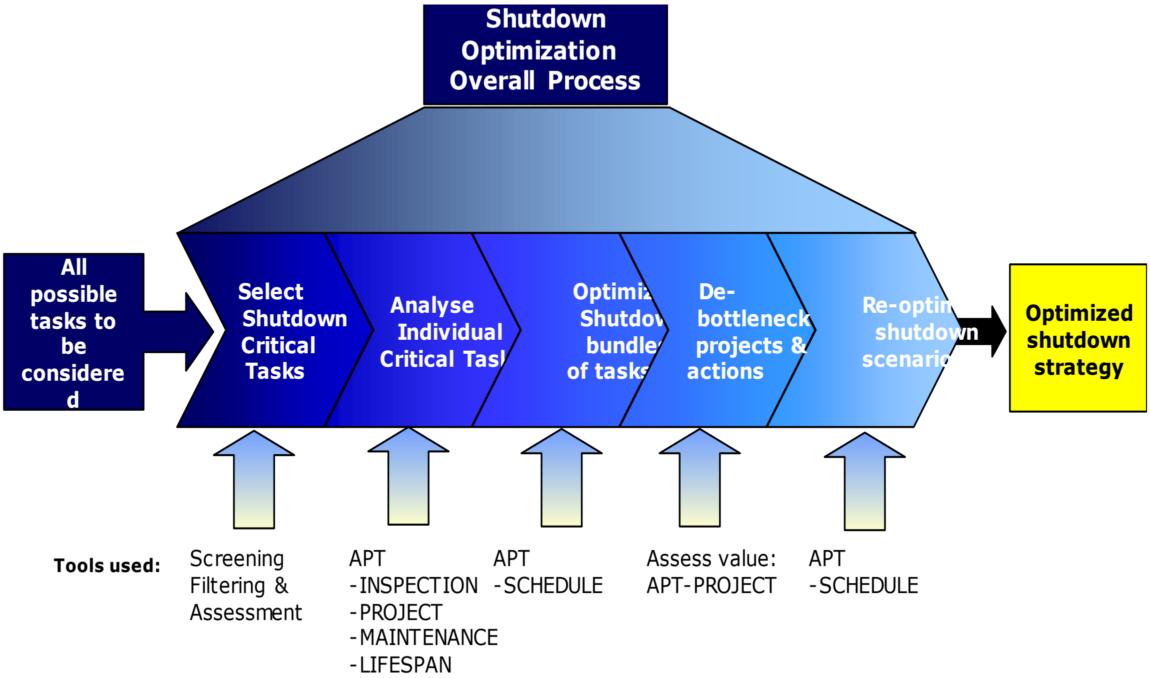

Figure 2 Shutdown Optimisation Methodology & Tools

	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**

Table 1 Filtering & Screening Results

From the table it will be noted that from a total of 24,260 tasks, 7,875 were listed as 'shutdown dependent' *yet only 86 were actually found to be truly shutdown dependent*. This result showed the extent of the shutdown cycle self-perpetuating habit described in the introduction above.

Analysis of Individual Tasks

The next step was to determine the optimal interval for each individual task. This can be a complex and difficult process, so APT[2] software tools were employed to model the risk assumptions and perform extensive "what if?" studies (given the inevitable lack of hard data).

When analysing optimal intervals we needed to be able to put a value to all direct and indirect costs. This is particularly difficult when assigning value to the consequences of failure, especially

[2] See www.decisionsupporttools.com

when dealing with health and safety, environmental or reputational consequences. This difficulty is compounded when there is uncertainty of associated assumptions. Great care was therefore taken by the study facilitators to extract tacit knowledge from the multi-disciplinary teams participating. Range-estimating techniques were used to set the bounds of possibility for uncertain data. Where this uncertainty caused the optimum to vary considerably, the quantified financial implications provided the motivation to search for more robust and accurate data or additional expertise.

Following individual task analysis, many of the tasks revealed optimal intervals equal to, or greater than a 4 year 'ideal target' interval. Others, however, showed optimal intervals which were less than 4 years – representing 'bottlenecks' to the achievement of longer shutdown intervals. An example of such a task is detailed below.

Example Task Analysis: Vent Pipe Cleaning

A typical shutdown-dependent task is the cleaning of the Phenol "vent header" pipe. This task is required because fouling of the pipe reduces process efficiency. Currently the task is carried out every 2 years. The task was analysed using the APT-MAINTENANCE module. The Total Impact results for different task intervals, with 'optimistic' and 'pessimistic' extremes of uncertainty, are shown in Figure 3 below.

The figure shows that, between pessimistic extreme and optimistic extreme, the optimal cleaning interval varies little (24-30 months) and a 4-year cycle would be much more costly in terms of performance constraints. Furthermore, the small variation in costs at the optimal interval showed there was no financial motivation to collect more accurate data.

Since the optimum interval for this task is less than the desired site interval of 4 years, we then evaluated the net cost of the 'bottleneck'. This is shown in Figure 4. Figure 4 shows the contributing factors in the 'most likely' scenario.

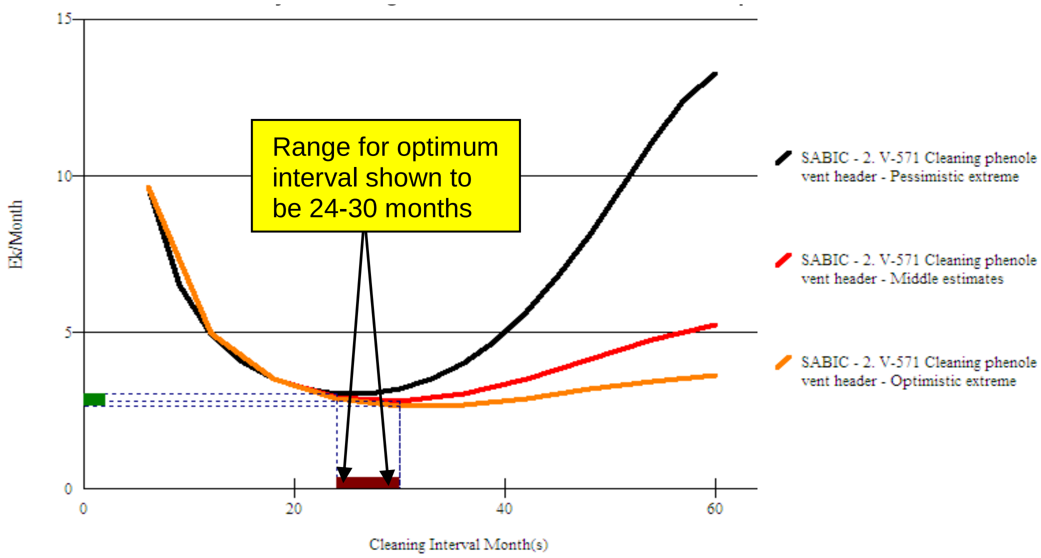

Figure 3 Range Estimates Vent Header Cleaning

In this case, the optimum interval is at 30 months, and the difference in total impact incurred by delaying to 48 months, is approximately €1,200/month or €14,400/year.

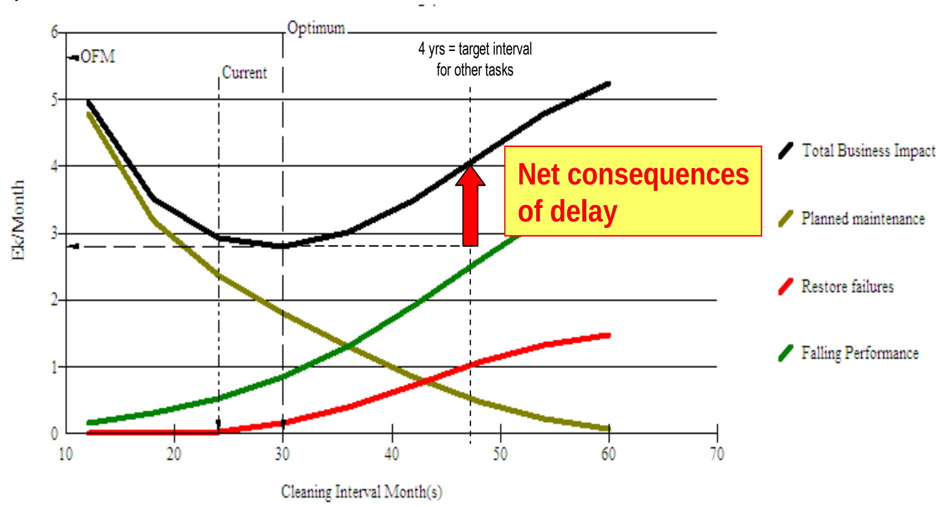

Figure 4 impact of Delaying Vent Header Cleaning

Optimising Bundles of Tasks

The next step was to assess the best way of combining tasks with different optimal intervals into the 'least compromise' groupings and shared timings. To conduct this extremely complex task the APT-SCHEDULE software tool was employed.

This module explores the effects of moving individual tasks away from their optima to share downtime or other bundling advantages with other tasks.

APT-SCHEDULE does this in "real time" in just a few minutes by utilising self-learning "genetic algorithm", normal simulation techniques would take around 4 weeks to 'solve' the optimal scheduling of just 10 tasks. There were 32 cost/risk- and timing-sensitive tasks carried forward to this 'optimal bundling and scheduling' stage, the results of which are shown in Figure 5.

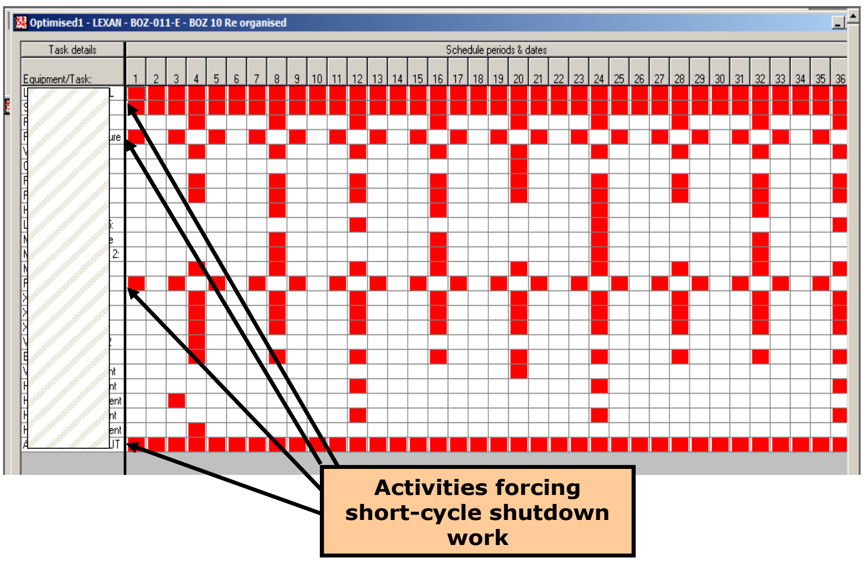

Figure 5 APT-SCHEDULE initial results

The results show that there were a number of tasks which still required and justified a frequent (annual or biannual) shutdown. The next step was therefore to "de-bottleneck" or remove the requirement for these high frequency shutdown dependent tasks. Table 2 lists some of the 15 de-bottlenecking actions identified for the Bergen op Zoom site; in most cases they represented very small investments, such as purchase of a spare equipment item to enable 'hot swapping' during normal operations.

production impact of this programme (and any alternative).

So the full impact of the changes was directly quantifiable – and represented 7-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 were able to commit to the revised plan very rapidly, and all de-bottlenecking actions were approved and underway within 2 months of the study. The Bergen op Zoom site is thus changing to the new, 4-yearly shutdown

Study	Describtion	ref.	Determining Failure mode	PM Frequency needed	Debottleneck timing	Possible sollution
CHL-041	GRP- Anolyte Knock-out drum	V14124	De-lamination of GRP	12 Month	ASAP	Order spare unit
CHL-045	GRP- Suction tank II , caustic service	V1471	De-lamination of GRP	12 Month	ASAP	Order spare unit ,
BPA1-001	Acid removal collumn	V510	Reduction in wallthickness	24 Month	re-clad within 30 Month	replace cladding of vessel
BPA2-046	Tar vent Pipe - cleaning	SW 2150	Fauling lost efficiency	18 month WC	at opportunity before next cleaning window	on- line / 50 % improvement
BPA2-021	Presure controll valve N2 service to Flaker line 1, planned inspection	PCV 21502120/1	If it is too low we stop the system (line 1 flaker), when the flow is too high we spill N2	12 month WC	at opportunity	Spare unit at stock
BPA2-024	Phenolic Recycle water breather, service on V21170, planned inspection	XC 21107103	Fauling lost efficiency	6 month WC	At opportunity / eliminate root Cause root	Spare unit at stock

Table 2 De-bottlenecking actions

Having identified the de-bottlenecking tasks and removed them from the task list, the APT-SCHEDULE analysis was re-run. The results of this are shown in Figure 6 (below).

This study revealed that the optimum shutdown interval is now 4 years. The APT-SCHEDULE outputs included a full NPV calculation of the costs, risks and

cycle as soon as these actions are completed.

Next Steps

The Bergen op Zoom project proved a great success and the process is now being rolled out to the other SABIC IP sites with the support of TWPL facilitators.

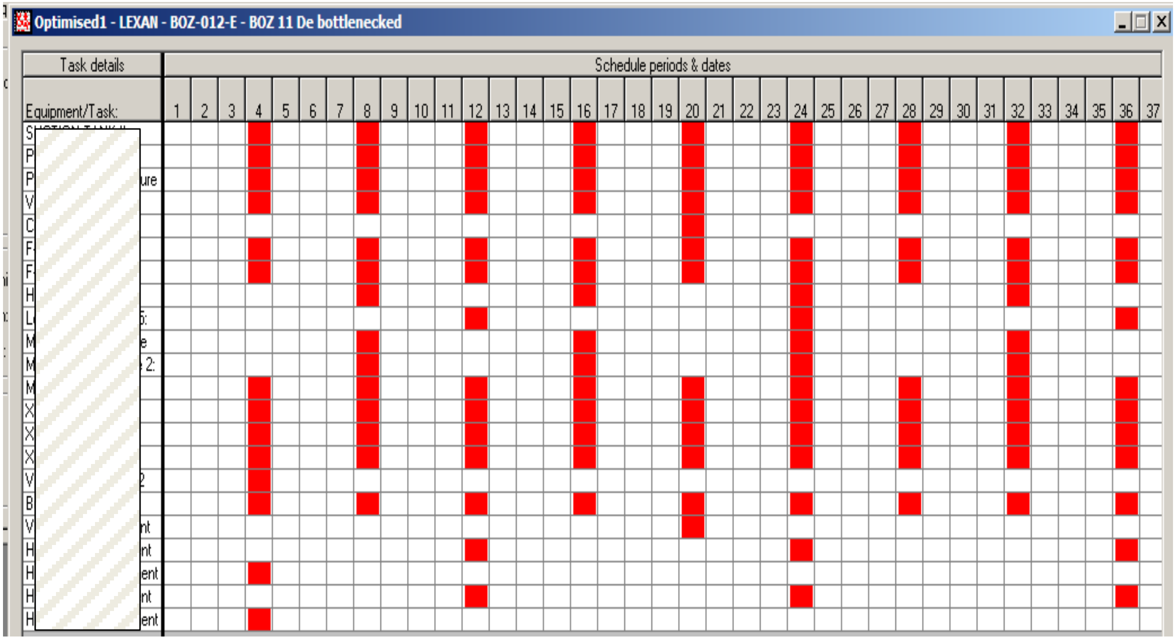

Figure 6 De-bottlenecked Schedule

Lessons Learned

When left unchallenged, shutdowns and their intervals become a self-fulfilling prophecy. Where this is the case, it is likely that the organisation's business processes will have evolved in order to support the pattern, concentrating on efficient delivery of the work rather than challenging its need and timing

Challenging the shutdown dependency of any task is essential, but can only be successfully done by competent multidisciplinary teams and full cost/risk appraisal, with appropriate decision-support tools and robust methods for coping with the inevitable uncertainties and poor information.

As with all change programmes the participation of all stakeholders was crucial. In particular, the safety-critical areas of inspection and Process Safety Management (PSM) were vital participants to the study. The structured range estimating and sensitivity analysis techniques were also major factors in obtaining confidence and credibility in the analysis results.

The credibility of the APT toolkit also helped: in contrast to 'decision support' that concentrates mostly on data analysis, APT was the output of the European MACRO R&D project that focussed on quantification of cost/risk trade-off when data is not available. They also enabled very comprehensive modelling of multiple, interacting risks to determine the best compromise position.

For more information

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