Assignment Case Study:

Shutdown Interval Optimization

The Client:

SABIC Innovative Plastics

The Objective:

To find, from first principles, the optimal plant shutdown strategy and thereby reduce costs, risks and lost production while still ensuring extremely high levels of plant integrity and performance.

Primary Results:

> Major shutdown interval extended from 2 years to 4 years
> Multi-million $$ annualised net savings/benefits
> Of 7,880 tasks scheduled for each typical shutdown, only 86 were found to be shutdown dependent and timing critical, and many were currently being performed at inappropriate intervals

Assignment Key Findings:

Analysis of the tasks scheduled for shutdowns revealed that over 65% of presumed shutdown-dependent tasks did not truly require a plant downtime – showing that shutdown workscopes and durations had grown significantly through adding of ‘opportunistic’ maintenance work that could have been done on-line.

Structured range-estimating of risks, performance and economic assumptions, plus rapid ‘what if?’ modelling using the APT tools, enabled efficient bundling of the critical tasks and identification of ‘bottleneck’ activities that force short-cycle shutdowns.

Removal of the need for these bottleneck tasks (by 15 procedure changes or minor plant modifications), enabled the shutdown interval to be extended from 2 years to 4 years, significantly reducing total costs and downtime losses while maintaining (indeed improving in several cases) plant performance and integrity.
The Total Business Impact of Shutdown Strategies

Why do Shutdowns?

It is widely understood that shutdowns are required to allow the completion of certain maintenance and engineering activities that cannot be undertaken when a plant or system is operational. It is also a well known fact that these shutdowns, outages or turnarounds, can consume huge resources and be extremely expensive, in terms of direct costs and lost production or system availability.

However, the true business impact of shutdowns and the interval between them is often not analysed in a systematic manner, and so opportunities to minimise the total business impact are often missed.

When to do Shutdowns?

Often the original reasoning behind existing shutdown intervals has been forgotten or has not been subsequently challenged through a disciplined process. Yet new technologies, materials, condition monitoring methods and maintenance/risk management thinking have radically changed the business impact, urgency and optimal timing for plant shutdowns.

Despite this changed environment, however, maintenance and engineering staff often see the next shutdown as an opportunity to catch up on the backlog of work or to ‘have a look’ whenever they get the chance. As a consequence, each shutdown can become ‘bloated’ with work that does not truly justify the costs and consequences of a full shutdown. Outage durations can become extended and assumed, though a cycle of self-fulfilling work planning. Often, nobody asks the simple questions about avoiding the need for shutdowns in the first place, or about opportunities to re-bundling the work into different, longer cycles. Cost/risk evaluation of individual tasks and their optimal timings are prerequisites for such reviews.

Minimising Total Business Impact

If shutdown intervals can be extended, however, the economic benefits are large and clear to all, but it is essential also to consider the associated risks and system performance impacts. The search must be: ‘What is the optimum interval between shutdowns?’ taking into account these risks and performance implications.

Figure 1 illustrates the relationship between the interval between shutdowns and all related costs and risks:

1. Preventive Maintenance and Shutdown costs: as the interval is increased, these costs reduce (per year)
2. Failure risks and performance losses: as the interval is increased, the exposure to these elements increase.

It is a common misconception that where these costs ‘balance’ i.e. where the lines cross, represents the lowest cost, or business impact. In fact it is the point at which sum of these two costs is at a minimum that represents the lowest potential business impact and is

The SABIC plant comprises a wide range of process units, handling highly critical and toxic chemicals. Safety, health, system integrity and environmental responsibility are therefore absolutely vital. This study exploited existing risk assessment work and Risk-Based Inspection studies, and obtained full support from the safety and inspection departments for the conclusions. The analysis process is not, however, limited to these types of environment: it has also been proven for outage planning in electricity networks, shutdown strategies for car tyre manufacturing, logistics optimization of work bundles for remote site visits and a range of other industries where optimal bundling of work is business-critical.
TWPL analysis process

1 - Define a Shutdown

In order to frame the analysis properly and filter out activities that do not really need a major outage, it was first necessary to agree a definition of a ‘planned 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 at least 50% production for a period of at least 24 hrs’

This filtered out the ‘pit-stop’ activities that could really be performed within the timeframe or production flexibility afforded by buffer stocks and spare capacity.

2 - Filtering the Current Task List

It was then necessary to filter the planned task list for those which genuinely require such a ‘proper’ plant outage to complete. This screening process was completed using a combination of simple rule-based screening (e.g. filtering out tasks assigned to equipment that has full stand-by redundancy, so such tasks that could really be performed during normal operations) and more complex assessments and structured challenges by a multidisciplinary team, facilitated by a TWPL expert. The screening reduced the task list from 7,880 tasks in the original ‘shutdown required’ list to only 86 that both genuinely required a plant outage and could significantly influence the shutdown timing.

3 - Optimising the Filtered Tasks

These were evaluated individually, using the advanced modelling methods of the APT toolkit, and the range-estimating and ‘what if?’ analysis process of the European MACRO project (Best practices in asset management decision-making: see www.MACROproject.org).

The APT tools were particularly invaluable as they were able to cope with the inevitable lack of hard data and allowed for various scenarios to be modelled efficiently, providing sensitivity analysis based upon the various inputs.

Figure 2 shows the output from such an analysis for cleaning a vent header pipe that becomes progressively fouled. The optimal interval is c.30 months, so a longer shutdown cycle (e.g. 4 years) would be unwise (+€1,200/month or €14,400/year). This indicates the potential ‘payback’ for an engineering modification to remove the constraint and enable longer run lengths.

Data uncertainty is a key, recognised element within the analysis process. All studies involved sensitivity testing to pessimistic and optimistic extremes. In this vent pipe cleaning, for example, the optimum interval was between 24 and 30 months across a very wide range of assumptions about degradation rates, failure and cleaning costs etc. (see figure 3).
4 Optimizing ‘bundles’ of tasks

Once the individual optimization studies were completed, the next step was to assess the best way of combining the tasks, with their conflicting individual urgencies and optimal intervals, into the ‘best compromise’ groupings. This process needs to consider and quantify the effects of deferring some activities and bringing forward others, to share ‘bundling’ advantages such as shared downtime, planning, logistics or resources. For any realistic number of tasks, this is extremely complex (just 10 planned tasks yield $10^{27}$ possible groupings and alignments) and required the unique APT-SCHEDULE analytical software to identify the best value work programme. Even modern high speed simulation techniques would have taken up to 4 weeks to complete such computations, but APT-SCHEDULE uses advanced ‘genetic algorithm’ techniques to learn what work groupings yield the best cost, risk and performance profile - in just a few minutes.

The section of results shown in Figure 4 reveals that just 3 tasks are truly needed every year, and a further 4 activities needed on a 2-yearly cycle, while others ‘map’ optimally onto cycles of 4, 6 and longer multiples. The 7 high-frequency (annual/bi-annual) activities were therefore identified as ‘bottlenecks’ to the objective of longer intervals between shutdowns.

5 Eliminating high-frequency tasks

The next step therefore, was to focus on these ‘bottleneck’ tasks and establish how their urgency could be eliminated, reduced in urgency or converted to on-line alternatives through plant changes, operational procedure changes or other solutions.

This brainstorming and systematic cost/benefit/risk evaluation of alternatives resulted in 15 actions, none of which required significant investment or radical changes to existing business processes. For example, some involved purchase of a ‘hot-swap’ spare (to enable rapid swap over during normal operations) or installation of a small bypass valve to enable on-line maintenance. All 15 actions received management approval immediately, due to the clear cost/benefit and risk impacts resulting from their evaluation.

6 Optimizing the whole schedule to minimise Total Business Impact

The APT-SCHEDULE study was re-run for the scenario without such bottleneck tasks, to determine the new optimal shutdown programme. Figure 6 shows that the resulting optimum interval now moves to 4 years (with some tasks every 2nd, 3rd or longer multiples thereof). The NPV (total business impact) of the change was calculated to be multi-million $\times$year, net of all costs, risks and performance impacts.

This result was endorsed immediately, and corresponding studies initiated across 3 other SABIC sites, using a TWPL template process to identify and adjust for differences between plant units, activities, resources, local culture, risks, costs and downtime criticalities.

For further Information please contact:

Julie Fowler
Education & Communications Department
The Woodhouse Partnership Ltd, Prince Henry House
Kingsclere Business Park, Hampshire
RG20 4SW United Kingdom.

Email: julie.fowler@twpl.com
Tel: + 44 (0) 1635 298800