Shutdown Maintenance Drivers under an Integrated and Business Focused Maintenance System

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Abstract*—**The ***purpose of this paper is to establish the drivers that guide or assist organizations with the need to have a maintenance shutdown in a cost-effective manner and in full support of the organizational strategies.

Design/methodology/approach – The emphasis of this research seeks to reinforce the connection between the organization strategies and the shutdown drivers.

Findings – The analysis results from a chemical manufacturing company in South Africa have been utilized in establishing the validity of the data.

Research limitations/implications – The establishment of the shutdown drivers may assist maintenance managers in planning and improving the plant's utilization of shutdowns and may contribute to substantial cost savings.

Originality/value – The approach in the paper adds important knowledge on shutdown maintenance drivers and how they relate to the organization's operational strategies.

***Keywords*—** Shutdown drivers, Value, Business Focused Maintenance, Operations Strategy.

I. Introduction

PLANT shutdown maintenance has been practiced by many manufacturing organizations for many years and without due care on what the drivers of the shutdown are. The obvious disconnect between the organizational strategies and the shutdown drivers is evident with many shutdowns being run merely on a repeatability basis of "we always have our shutdown during this time". With the globalization of the economy and erosion of profitability in some manufacturing sectors of the economy, the maintenance budgets of many organizations have been put under the spotlight by the top management, and this have put pressure on shutdowns to be cost effective. In these days many manufacturing organizations have embarked on Enterprise transformation models and the global economic landscape has compelled many manufacturing organizations to embark on the enterprise transformation models in order to remain viable and these include the following among others:

1. Business model re-engineering whose main goal is to achieve breakthrough solutions that bring radical changes to the business process. The objective is to increase enterprise performance and customer value [5]
2. Asset Management which is the management of primarily physical assets, their selection, maintenance, inspection and renewal. It represents a cross-disciplinary collaboration to achieve best net, sustained value-for-money in the selection, design/ acquisition, operations, maintenance and renewal/ disposal of physical infrastructure and equipment.[18]
3. Theory of Constraints that has the focus of eliminating bottlenecks and increasing throughput of a manufacturing firm through continuous improvement. The objective is to improve the financial performance of the core enterprise [3], [5]
4. Lean System which seeks to eliminate waste through customer focus, value stream focus and creating a flow and pull system in the enterprise product realization process(es). It is an evolutionary and systematic change process that seeks to deliver value to all stakeholders. [2]
5. Value Management whose goal is to increase return on investment to the enterprise. Its main focus is on functional analysis and function worth. This is an incremental and innovative change process whose objective is to increase value to customers and stakeholders[15]

For companies (e.g. oil and gas, pulp and paper, and chemical industries) that run continuously, shutdowns and outages consume a lion's share of maintenance and capital budgets. [17] Also commonly known as a plant overhaul, the temporary shutdown of a production plant or factory is an enormous undertaking and one that requires careful and systematic planning prior to performing the task. Any temporary shutdown of a plant or factory is an extremely expensive occurrence, whether emergency in nature or planned for two years. Studies have demonstrated, however, that the short-term expenses are more than offset by improved plant efficiency, improved operations, lower energy use, and markedly fewer unexpected mechanical failures. [19]

Major cost items come in three flavours in a factory, processing plant or other large facility and these are:

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1. Capital investment, including building, expanding a plant or facility
2. Catastrophic breakdowns, forced shutdowns, and large accidents, fires or explosions
3. Intentional scheduled shutdowns, outages and turnarounds [1]

The first is subject to intense scrutiny/justification and, with the exception of the patchy adoption of life cycle costing, is pretty much understood. Many organizations are trying desperately to avoid the catastrophic events — and have been grappling with systematic and quantitative analysis methods for many years (HAZOP, QRA techniques, risk-based inspection etc.). The third area, planned shutdowns, is still an enigma for many organizations. [12]

A shutdown/ outage involves a project team that might consist of maintenance managers, maintenance engineers, project engineers, maintenance artisans and planners. Another target audience consists of contractors who participate in shutdowns. They may be in total turnkey control of the shut or may simply supply labour to the event. [4]

There has been pressure for shutdowns and projects to deliver the value for which they are executed. For many organizations, the Key Characteristics of Unsuccessful Projects have been defined as:

- Failure to deliver the Business Value
- Higher than expected Maintenance Costs
- Suffered budget overruns [15]

The Reasons for missed Value have also been pointed out as: Poor planning (including time or resource estimates); Unclear goals and objectives; Lack of project sponsor and stakeholder involvement; Breakdown in communication; Time & Budgetary constraints; Tactical vs. Strategic approach; Ill-defined problem and unclear scope; Lack of consensus among stakeholders; Disconnect between Capital & Operating budget and Political influences & improper Risk Analysis [15]

According to Value Management model:

$$\text{VALUE} = \frac{\text{FUNCTION}}{\text{COST}}$$

Where:

Value = reliable performance of functions to meet customer needs

Function = natural or characteristic action performed by a product or service

Cost = expenditure necessary to produce or maintain a project, service, process [5]

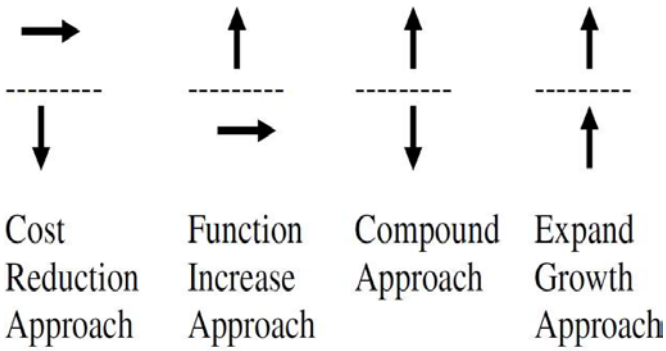

Fig. 1 Value E ngineering Approaches. [5]

II. The Need For Shutdown Maintenance

Over the years, Plant Maintenance Shutdowns have been a pre-requisite for many manufacturing firms as various maintenance drivers push for shutdowns as and when circumstances call for it. A shutdown is a major task that has a significant business impact. Shutdowns are expensive because they are labour and material-intensive and because they take productive capacity off-line. It is imperative that shutdowns are carried out quickly and effectively to minimize negative business impacts. [14]

Plant shutdown for major maintenance on a periodical basis is not merely an insignificant technical event that is carried out by the maintenance function from time to time. It is in fact an integral part of any company's business plan, which will directly cause major impacts on the company's business performance. It is playing a pivotal role in ensuring the equipment reliability, production integrity as well as workers personal safety. [1]

Plant shutdowns for scheduled major maintenance work are the most expensive and time consuming of maintenance projects because of the loss of production and the expense of the turnaround itself. The planning, preparation and execution of a shutdown/turnaround is a complex undertaking that demands effective strategies and attention to details. It also requires a profound understanding of the critical elements to ensure successful turnarounds as well as the drivers and constraints that shape the event. [1]

Effective shutdown management is critical to the operation of mills, for without well-planned and executed shutdowns, equipment reliability suffers, and the mill pays the price in poor quality and lost production. Becoming proficient at managing shutdowns is a way to reduce overall downtime costs so that shutdowns themselves do not consume the savings they are capable of generating. [12]

Due to current economic conditions, cost cutting has become a high priority, and effective shutdown management is an exercise in such waste reduction. Maintenance shutdowns are a major part of the annual budget at most mills and are usually a target for cost reduction.

A company can schedule a shutdown service as a preventative measure to help maintain the life of its equipment. This is done when either an entire plant or section of a plant shuts down its processing. At such time, the maintenance of

current installations and/or of new installations can be conducted. [9]

III. Types Of Shutdowns

Depending on the industry a shutdown can be different in scale, for example:

- Several weeks for a stop in an oil refinery.
- Days for a longer shut down in a chemical plant.
- Hours for a recurring shut down in many process industries.
- Minutes for adjustments and tool changes in manufacturing industries.
- Seconds for a Formula 1 or NASCAR pit stop.[10]

Shutdowns provide unique opportunities to a maintenance department not normally available during standard operation or even during short shutdown periods. Broadly, Shutdown Maintenance consists of two main categories and these are:

1. Proactive - Planned shutdown maintenance, and
2. Reactive - Incidental/ Opportunity/ Unplanned shutdown maintenance

Proactive and Reactive shutdown maintenance differ broadly in the way jobs are scheduled before and added after the shutdown. Reactive/Incidental shutdown occurs for example, when preventive maintenance on some equipment is pushed forward to take advantage of a process outage gap. Thus incidental shutdown is an opportunity shutdown maintenance that is carried out as and when an opportunity avails itself, e.g. power outage for prolonged periods, or raw material outage from upstream operations or a full-ahead situation.

Proactive/Planned Shutdown work identification is an ongoing activity and effectively starts the day after the previous shutdown is completed. A large portion of the actual work included in the scope of any shutdown is either [11]:

- Repetitive from shutdown to shutdown (e.g.: catalyst bed changes, filter media replacement),
- Mandated by regulatory bodies (e.g.: vessel inspections, relief valve tests), or
- Drawn from the long-range facility plan (e.g.: capital improvements, major equipment overhauls).

There will also be a number of activities identified during condition-based-maintenance, on-the-run inspections or identified by operations or maintenance personnel in the normal course of operation.

IV. Planned Shutdown Maintenance Drivers For Manufacturing Organizations

Scheduled maintenance is more cost effective than unscheduled maintenance. All machinery at one point or another need to be either cleaned, maintained or repaired. By organizing a scheduled 'shut-down', many services can be provided at once, production halt is controlled which in turn, reduces the downtime of machinery throughout the year. In addition, insurance companies value such preventative maintenance and may offer reductions in insurance premiums. [10]

To make the best decisions in preparation for and during shutdowns, it is important to know what makes your business or organization tick. Shutdown projects and project strategies flow from a thorough understanding of what most influences your business (that is, what are the dominant patterns such as growth, cost avoidance, safety, efficiency, etc.). These influences are usually a mixture of external factors that must be forecast or predicted, and internal factors over which you have various degrees of control.

In recent years, methodologies like MACRO [12] have yielded a suite of methods for cost/risk/performance trade-off decisions — such as optimal maintenance or inspection intervals, equipment renewal or upgrade justification, shutdown strategy, spares requirements, etc. In each of these areas, a blend of innovative, risk-based evaluation techniques have been developed alongside structured guidance "rules". These have been developed and proven in field by those faced with the decisions (i.e. not some academic theoreticians). [12]

Much effort has gone into the efficient planning and delivery of the work involved in planned shutdowns, but relatively little guidance exists for determining what drives the need to have a planned shutdown, what work is worth doing in the first place, and how this should be clustered into appropriate packages to share shutdown opportunities. A surprising number of organizations (particularly in the utilities and service areas of operation) still do not even know how much a shutdown costs them. [12] Unless there is value that is ***unlocked in having a maintenance shutdown, then there is no need to have a shutdown.***

Shutdown drivers are forces behind tasks required to support an organization's operational goals that can be executed while the process is down.

The long term strategy provides the overriding philosophy regarding facility outages and encompasses short, medium and long term periods. It links items such as [10]:

- the organizational growth plans
- its marketing plans with its facility improvement
- upgrade plans
- its overall asset management and maintenance plans. It is used to aid the long-range budgeting cycle and will aid in balancing activities from one year to the next.
- The strategy will define the overall approach to shutdowns and will provide guidelines regarding issues such as inspection intervals, preference for unit shutdowns vs. complete facility outage, etc. The strategy will also lay out the requirement for resources over the long term and can be used to balance the requirements across various time frames including those for contractor support where needed.

A. Key Performance Indicators Of A Successful Shutdown

An effective system for the shutdown maintenance should meet the following objectives.

- Manage and prioritize all the work initiated according

to the scope
- Achieving the budgets.
- Able to achieve the schedules
- Manage site/plant access for resources, vehicles, equipment, and tools.
- Manage indirect hire, contractor, subcontractor, and service personnel at the site/plant. [7]

If the objectives in any one of these areas have not been met, we cannot call the shutdown successful. NASCAR is a good example of what can be accomplished through precision planning and scheduling and execution with pit stops improving from 240 seconds in the 1950s down to the record levels of 12.6 seconds where it is today. Major contributors to their pit stop, or shut down performance, include operations and maintenance communication and continuously working on improving the basics of Planning and Scheduling, Execution and Root Cause Problem Elimination. [10]

It does not matter whether we are looking at a paper machine down-day or a total petrochemical complex turnaround. There are a number of common factors in the success of the shutdown activity.

V. Shutdown Maintenance For A Chemical Manufacturing Company In South Africa

The chemical manufacturing company in South Africa runs on 24hours – 7 days a week basis on a continuous flow processing system. For many years spanning over 10 years, the organization has been consistently carrying out an annual shutdown maintenance running for a two weeks duration and also a one-day 3-monthly shutdown maintenance. The 3 monthly shutdowns have been held on a one day duration, but occasionally shut overruns have been experienced with the one day shutdown running into three days due to emergent maintenance work during the shutdown period. In the year 2012, the annual shutdown also overran by four days over the planned period due to the overwhelming emergent work during the shutdown. Cost containment has always posed a great challenge to shutdown maintenance for the organization such that eventually it was resolved that the annual shutdown maintenance has to be held during the first quarter of the financial year so as to afford the organization enough time to seek additional funding in case of the maintenance overspent on the fiscal maintenance budget.

A. Shutdown Maintenance Drivers For The Organization

After going through the shutdown maintenance process planning for the South African chemical manufacturing organization, it was revealed that the shutdown drivers were as follows:

1. Preventive maintenance on the rotary kiln:

The rotary kiln was established as the most business critical kit of equipment for the organization in that it was a single unit in the product realization process for the organization and it had no redundancy for standby capacity. If it broke down, then the production process for the whole organization stopped. Therefore the scheduled inspection and replacement of wearable components of this critical kit of equipment had been the major driver of annual shutdown maintenance for the organization.

2. There was also a three monthly shutdown maintenance that was found to be mostly driven by the finishing department's preventive maintenance on the value stream equipment with no redundancy where scheduled replacement of wearable components took place
3. There have also been a number of activities identified during condition-based-maintenance, on-the-run inspections or identified by operations or maintenance personnel in the normal course of operation that have resulted in shutdown maintenance being carried out.
4. No safety or legal compliance mandated by regulatory bodies (e.g.: vessel inspections, relief valve tests) drivers existed for the organization as equipment falling in the category could be maintained during the run.
5. There has been shutdown maintenance drawn from the long-range facility plan when the company was involved in capital improvements which involved SCADA system and PLCs upgrade.
6. Cost consideration fitted in the bottom rung of the shut planning process as the shut was mostly planned on a "what needs to be done" basis.
7. The traditional approach to shutdown planning at the organization has been to have the shutdown maintenance on a preventive maintenance fixed time basis (Repetitive from shutdown to shutdown) with no relationship to operational strategies.

B. Key Performance Indicators For The Organization

The South African chemical manufacturing organization's shutdown maintenance key performance indicators were found to be:

1. Managing and prioritizing all the work initiated according to the scope of the shutdown maintenance
2. Ability to achieve and complete the maintenance schedules planned for during the shutdown
3. Managing site/plant safety and environmental compliance for employees and contractors
4. Managing indirect hire, contractor, subcontractor, and service personnel at the site/plant.

VI. Strategic Considerations That Drive Shutdown Maintenance In An Integrated And Business Focussed Maintenance System

After analysis of findings at the South African chemical manufacturing organization, it was found that the following strategic link existed between the organization's operational strategies and the shutdown maintenance drivers and the drivers should have been considered during the shutdown maintenance planning process.

The long term strategy provides the overriding philosophy

regarding facility outages and encompasses short, medium and long term periods. It links items such as

1. the organizational growth plans
2. its marketing plans with its facility improvement
3. upgrade plans
4. its overall asset management and maintenance plans. It is used to aid the long-range budgeting cycle and will aid in balancing activities from one year to the next.
5. The strategy will define the overall approach to shutdowns and will provide guidelines regarding issues such as inspection intervals, preference for unit shutdowns vs. complete facility outage, etc. The strategy will also lay out the requirement for resources over the long term and can be used to balance the requirements across various time frames including those for contractor support where needed. [11]

The shutdown maintenance drivers that should have been considered by the South African Chemical Manufacturing Company are detailed as below:

Changes in market demand (new products or need for increased capacity)

Meet a competitive challenge

Meet an expanding market

Open a new market

New products are constantly being invented, and old plants are adapted to current needs and shutdowns are designed to change the plant's output.

Profit enhancement (efficiency improvements to save money or reducing the cost of making what you already sell)

Operational efficiency

Energy efficiency (Natural gas is expensive but clean, and oil costs go up and down)

Reduced scrap or increased yield (major driver of the semi-conductor industry)

E.g. South African gold mines invented a process that extracts more gold from ore than before. [14]

Maintenance need (replacing worn out assets) is one of the most common drivers of shutdowns. Maintenance need might be based on PM inspections (wear plate), NDT (tubes are too thin), history (we rebuild this every 4 years), even gut feeling sometimes.

Increase reliability

Increase repeatability

Increase or augment life-span

The work, which is to be carried, should be clearly identified. The work identification depends upon the following points.

- The number of failures
- The root causes of those failures
- The Maintenance costs associated with those failures
- The Production costs associated with those failures - note that these may incorporate more than just downtime costs.
- Any Safety or Environmental implications associated with those failures.

VII. Conclusion

Under the current business environment, cost competitiveness and effective maintenance management is key to corporate strategy. The failures of equipment have led to high maintenance and operational costs. Shutdown Planning is a mega activity in the continuous running plants, and the timing and management of a shutdown have to be carried out within the strategic confines of an organization running under an Integrated and Business focussed maintenance system. The organizational strategies have to drive the need to have maintenance shutdowns and it is no longer the time to have shutdowns just because "we have always been doing it that way". Thus a shutdown project has to achieve the VALUE for which it was carried out. It is expensive to afford unplanned downtime!!

References

[1] Levitt, J, 2004, Managing Maintenance Shutdowns and Outages, Industrial Press, New York, First Edition
[2] Wiegand B., Langmaack R.,and Baumgarten T., Lean Maintenance System, 2005, Druckerei Schworer, Mannheim, Germany
[3] Moore R., 2007, Selecting the right manufacturing Improvement Tools: What Tool? When?, Elsevier, MA United states of America and Oxford, UK
[4] Moore, R., 2004, Making Common Sense Common Practice: Models for Manufacturing Excellence, Boston, MA and London, England: Elsevier Butterworth-Heinemann,
[5] Institute for Defense Analyses, 2007, Value Engineering Handbook, Virginia
[6] Lenahan T., 2013, Turnaround, Shutdown and Outage Management: Effective Planning and Step-by-Step Execution of Planned Maintenance Operations, Butterworth Heinemann
[7] http://en.Wikipedia.org/wiki/
[8] http://www.industrialpress.com
[9] http://www.lean-management-institut.de
[10] http://www.bls.gov
[11] http://www.slideshare.net
[12] www.twp.co.uk
[13] http://www.idcon.com 14. http://www.pem-mag.com
[14] http://www.value-eng.org/value_engineering.php
[15] http://www.grainger.com
[16] http://www.LCE.com
[17] http://www.theiam.org
[18] http://www.nytimes.com
[19] http://www.journals.elsevier.com/case-studies-in-engineering-failure-analysis/
[20] http://www.ein.org.pl/sites/default/files/2013-04-23.pdf