A Holistic System Approach for Turnaround Performance Management

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A Holistic System Approach for Turnaround Performance Management

Umar Al-Turki*, Salih Duffuaa and Mohammed Bendaya

Department of Systems Engineering
King Fahd University of Petroleum & Minerals
Dhahran, 31261
Saudi Arabia
*Corresponding author: Umar Al-Turki
e-mail: alturki@kfupm.edu.sa
e-mail: duffuaa@kfupm.edu.sa
e-mail: bendaya@kfupm.edu.sa

Abstract

Turn-around maintenance (TAM) is a major event that impacts a whole supply chain as well as other external stakeholders. In the current practice turn-around is planned and executed at the individual plant level in isolation from the other members in the supply chain. The purpose of this paper is to develop a framework for planning, scheduling and executing TAM taking into consideration the needs of all stakeholders network (system) including the supply chain in which the concerned plant is part. The members in the supply chain include; end user customer, upstream plants, downstream plants, and raw material suppliers. The proposed framework integrates the planning and scheduling among stakeholders in the supply chain in terms of objectives, goals and performance measures. The proposed framework helps in developing a holistic approach for planning and scheduling that takes the needs of all stakeholders in the supply chain into consideration.

Key words: Turnaround Maintenance, Performance Management, Systems Approach, Turnaround Planning.

1 Introduction

Turnaround Maintenance (TAM) is a crucial activity in process industry where a periodic plant shutdown is done to allow for inspections, repairs, replacement and overhauls. Many industries, such as chemicals processing or power generation, may have a continuous demand to produce products that cover a wide range of customers. Hence, TAM is needed to sustain a reliable process for the whole supply chain.

TAM projects are, in general, divided into several sequential phases that include validating work scope, pre-shutdown work, planning and organization, execution, and termination. These phases are cascaded to more detailed steps at each phase to achieve an effective TAM. Lenahan (1999; 2006) addressed fewer TAM phases: initiation, preparation, execution and termination. For more details, readers may refer to the following books [Duffuaa et al. (1999); Levitt (2004); Lenahan (1999; 2006); Brown (2004)].
TAM projects are huge projects in terms of manpower and financial expenditure. The industrial processes that undergo TAM projects are often of high value and their maintenance operations are intensive, complex and costly. A recent example by Shell shows that TAM in Athabasca Canada required thousands of workers in its peak, extended beyond planned duration by eight weeks and averaged to the tune of hundred million dollars (Pokharel and Jiao, 2008). It is therefore vital that TAM is planned and executed effectively.

In the arena of globalization and mass economy, business is getting more competitive and interconnected giving rise to giant corporate dominating small businesses. In that kind of business environment, managing assets becomes highly critical in surviving and maximizing profit. In that environment, the traditional project management view of TAM needs to be replaced by a more global business view that takes into consideration the whole network of interconnected organizations including the production supply chain and other supporting services. The literature on TAM planning and scheduling is mostly concerned about TAM at the plant level, and recently at a strategic level, but falls short in addressing this issue.

The purpose of this paper is to develop a new planning approach for TAM that takes into consideration the whole production supply chain as well as other stakeholders. Section 2 provides a brief survey of the literature on TAM planning. Section 3 develops the system view of the TAM activities which identifies the supply chain as well as the stakeholders. Section 4 defines the objectives and performance measures at the global level in relation to individual unit objectives and measures. Section 5 discusses some supply chain principles and best practices that would have an impact on the global system efficiency and effectiveness of TAM. Section 6 concludes the paper.

2. Literature survey

TAM planning at a global level as explained in the introduction is, as far as we know, nonexistent in the literature. In the other hand, the literature on production and inventory planning and management at the supply chain level is quite mature. The literature on TAM is mainly focused on strategic, long and short term planning and scheduling. In this section a brief preview of the literature on TAM planning will be reported for setting the stage for global holistic planning approach.

It is essential to link maintenance strategy to the organization mission and objectives. Dyke (2004) suggested various steps that need to be taken to improve turnaround performances covering the strategic objectives, reliability and availability, management of risk, and time and cost management. He also used, to improve TAM, benchmarking that involves data gathering, workshops, interviews, informal discussions, review of procedures and systems, and site inspections. Nath and klingler (2009) presented, in the case of chemical cleaning, a strategic discussion on turnarounds covering the timeframe to clean equipment; safe environments for maintenance personnel; team strategy; best practices to shutdowns; best practices related to cleaning technology and vendor personnel; defining key planning deliverables; dedicating manpower resources; executing and archiving the plan; and documenting lessons learned for future turnarounds. Mayo (2009) discussed turnaround strategy and how to achieve both predictable and competitive turnaround cost and schedule.

Long term planning for TAM program should coincides with the organization strategic plan. A recent trend in the literature spots the importance to look to the maintenance function at
strategic level. Tsang (2002) identified four strategic dimensions of maintenance: service delivery options, organization and work structuring, maintenance methodology and support systems. These dimensions should be linked with plant strategic plan in order to have the best suitable selected maintenance alternative. Murthy et al. (2002) addressed the need for data collection in strategy selection. Al-Turki (2011) developed a framework that puts elements of strategic planning together. The framework studies the involvement of major stakeholders as well as top management in the strategic maintenance plan. It also urges commitment of senior management for the successful development of a maintenance strategic plan. Principles for strategic maintenance planning can be considered in TAM planning.

Contractors for TAM plays major role in planning. Ghazali et al. (2011) proposed a multi-criteria decision model as a mean of facilitating contractors' selection for a petrochemical company in Malaysia. They should have technical know how about the scope of work set up for contracting. They need to guarantee availability of skilled and specialized man power to deliver the work to be contracted. They should also satisfy: quality of work, reliability in delivery, availability to meet safety requirements, flexibility to respond to unforeseen circumstances, compatibility of contractor system with company system. High performance contracting was suggested by Singh et al (2012) to improve TAM program in addition to active involvement of all plant departments; team building alignment, mechanical work window, performance evaluation.

TAM budget should cover manpower cost, equipment and material, contingency plan. To control TAM work budget, Motylenski (2003) presented methods with an overview of the practices successfully applied in planning and executing turnarounds that resulted in reduced turnaround cost and shorter downtimes. Key to an effective and efficient turnaround is proper and early planning. An effective work plan is achieved by early development of an overall milestone plan called "planning the plan". Roup (2004) reported a discussion covering important plant manager responsibilities to control TAM budget. He reported nine key strategies of pacesetter turnarounds, i.e., single-unit turnarounds, limited scope of work, risk-based inspection, short schedule, small and experienced workforce, operations' ownership and costs, cohesive team, schedule focused on critical path, and well planned with key milestones. Reiland and Busick (2011) presented a methodology to effectively monitor basic project parameters to improve turnaround predictability and performance. This study is applicable for any type of facility (onshore, offshore, etc.) that undergoes periodic outages for maintenance and capital improvement for long term performance of the facility (asset). Schroeder and Vichich (2009) studied fundamental relationships illustrating the impact of specific trade-off decisions upon overall economic viability of the turnaround. The relationships include the major cost-contributing factors in TAM such as shift-patterns, labor productivity, and turnaround duration, fixed costs, quality and lost opportunity costs, and generic turnaround trade-off model.

Short term TAM planning covers all needed resources for successful TAM implementation. Oliver (2002) stressed the need of TAM planning to address the specific challenges that are parts of repairing process equipment In addition, it is necessary to design a number of criteria to provide balanced indication of performance. It includes: TAM budget, spare parts suppliers, contractors, and site logistics.
3. System Development

The objective of this section is to develop a global view of TAM in terms of its stakeholders and their relation to its planning and execution. The core of TAM where plans are developed and executed is the unit within the plant in charge of the project. Figure 1 shows a system view for TAM for any given plant (unit).

![Figure 1: TAM System view](image)

Within the plant, TAM plans are prepared with enough lead time for all preparation, coordination and arrangements to be done before the actual start of execution. All necessary arrangements with external suppliers and contractors are to be done to secure on time delivery of equipment, spare parts, etc., and assuring the availability of the human resources with the right combinations of qualifications and skills. Similarly, financial resources, technical, managerial and IT expertise has to be secured internally for controlling and monitoring all TAM operations. Execution should then start at the pre set time and continues based on a schedule controlled and monitored by a group of project managers to ensure timing and quality and to be ready for any correction actions and emerging situations. Success is measured in terms of achieving the predefined objectives in terms of outcomes as well as in terms of execution. Success of execution is mostly measured in terms of meeting the schedule within the preset budget in the right predetermined quality. Success of outcomes is usually measured in terms of having a safe and reliable plant in addition to compounded experience build up for future TAM operations and continuous plant performance improvement.

In a larger context (corporate level) the system consists of several plants connected in series, where the output of a plant is fed to the next plant or in parallel where each plant is independent of the other. These plants can be producing raw material or finished products in the petrochemical industry. The plants can also be refineries in the oil industry for any oil producing and processing company. In case of series of plants feeding each other with raw material (sub-products), a buffer or a stock of the material is maintained for continuous uninterrupted production. Final products are passed to external customers without shortage or delay. TAM planning for each plant draws upon a set of resources from different sources, internal and external, such as subcontractors, spare parts suppliers, and technology providers. TAMs are highly labor intensive with various types of skills and capabilities and usually secured through external subcontracting. Spare parts of different technologies are needed to
be available at the right time and need to be ordered from different sources taking into consideration lead times and financial commitments. The support and consultation is usually needed to be available from technology providers before, during and after TAM. Figure 2 shows all stakeholders of the TAM at the corporate level. The supply chain in the lower part of the figure starting from raw material suppliers to end product customer with buffers (stocks) inbetween plants can be within a single corporate organization and hence share the same resources within the organization. External stakeholders such as contractors, sparepart and technology providers may be shared by all plants within the supply chain. Hence a shutdown in one of the plants may affect all other plants as well as external stakeholders.

Integrated TAM planning and coordination secures a maximum utilization of resources at the global system level as well as maximizing the global objective of the entire system that includes internal and external stakeholders.

![Figure 2: TAM multi plant system view](image)

For the global system to be integrated for serving the global objective of the supply chain, several issues has be addressed and built within the system. These issues are as follows:

1. Coordination with supply chain partners
2. Shutdown effectiveness
3. Learning process and sharing of best practices with similar industries

Each of these issues is discussed below for better understanding and integration.

3.1 Coordination with supply chain partners

A plant undergoing TAM has an impact on, and impacted by, all other supply chain partners including:

- Upstream plants providing raw materials;
- Downstream plants using the plant products as raw materials;
- Vendors providing spares and long lead time items;
- Contractors providing manpower; and
• Final customers buying the plants products.

High level coordination within the supply chain at all TAM stages helps in maximizing benefit within the whole supply chain. Coordination within the supply chain can go to a level of deciding on the timing of the TAM for each plant, upstream and downstream, as well as sharing information during the stages of TAM and afterwards. This coordination can be through common committees or task forces at the planning level. Mathematical models and other scientific tools may be utilized for optimizing time TAM windows and costs. Such committees might get in contact with vendors and contractors for building strong long term relationship. Establishing such relationship with suppliers and contractors secures benefits to all parties and resolves conflicts effectively ahead of time. At the end of the supply chain comes the end customer that sets the requirement for the whole supply chain. Obviously that requirements is largely a major driving force for the whole supply chain. To enhance the communication process within the supply chain, an integrated information system that links all these partners together should be developed and forms the backbone for timely effective coordination. This coordination and information sharing is highly needed during TAM execution to secure fast response to unexpected events by other partners.

3.2 Shutdown effectiveness

The overall objective of TAM is to ensure high plant safety, reliability and availability. Therefore, conducting a TAM within schedule and budget may not be enough. In addition to operational measure of budget and schedule, there is need to also emphasize and implement plant effectiveness measures. At the plant level, measures of TAM success has to be set, monitored and utilized for future plans. Such measures should be in line with high level objectives of the organization and agreed upon at the plant level. Having similar measures across the plants within the organization helps in coordination and sharing information across different plants. Including some high level measures that impact the organization helps in optimizing TAM at the global (system) level. Measures should be effectively utilized for improving the TAM process at the plant level and a global level in future plans and executions.

3.3 Learning process and sharing of best practices

A formal process for documenting positive and negative experiences during TAM planning and execution should be established. The result should be shared as a best practice document that will enhance the learning process across the organization. Failing to feed back this accumulated experience to the system for future improvements is a major shortage in current TAM practices in the industry. A platform or a mechanism for sharing best practices across the supply chain should be established and systemized to ensure gaining the expected benefits. This learning process can be extended to other partners (suppliers, contractors and vendors) in terms of the technical know-how for design and technical specifications of equipment and spare parts.
4. Objectives and Performance Measures

A Supply Chain is a network of organizations that cooperate to maximize the value generated by improving material and information flows among suppliers and customers at the lowest cost and the highest speed. This effort can be measured by sustainable profitability. Although profitability of the supply chain is important, however within the chain may exist some organizations that compete to maximize their return on investment (ROI). This overall objectives of the chain may be supported with tactical objectives that include:

- Improving customer satisfaction.
- Improving product quality.
- Minimizing the time required for converting orders into cash.
- Minimizing the total Work-In-Process (WIP) in the Supply Chain.
- Improving visibility of demand by each one of the partners.
- Reducing costs.
- Enhancing services.

In order to assess the strategies for achieving the above objectives many supply chain performance measures are proposed and used. Gunasekaran et al. (2004) proposed a framework for promoting better understanding of supply chain performance measures. Gunasekaran et al. (2001) developed performance measures with emphasis on supplies but he attempted to relate them to customer service. Kleijnen and Smits (2003) provides a survey and a critical review of supply chain management metrics.

In this paper it is proposed to align the objectives of TAM with the overall supply chain objectives. The following objectives are suggested for TAM:

- Maximize productive capacity.
- Improve product quality.
- Enhance equipment reliability.
- Minimizing operation cost, and reducing downtime.
- Cope with legal and safety requirements.
- Enhance cooperation among partners, access and usability of past TAM maintenance knowledge base.
- Improving accessibility and usability of best practices.

The current state of TAM measures is mostly operational to assess conformance to the planned activities. The current utilized measures do not focus on plant performance measures let alone the supply chain measures. Our purpose in this section is to tie the TAM maintenance performance measures to the supply chain overall goal and objectives. The following TAM measures are proposed and can be mapped to the supply chain performance measures:

- Information availability, accessibility and usability.
- SM duration
- Reliability with six month TAM.
- Quality rates.
- Process rate.
- Availability of major machines.
- Spare parts lead time
- Overall equipment effectiveness
- Utilization of resources.

Table 1. shows the alignment between supply chain measures and TAM measures. The circle indicates a strong alignment or influence of the TAM measure on the supply chain measure while the triangle indicates moderate alignment. The selection of the overall TAM measure must be based on the alignment with supply chain measures.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Improving customer satisfaction</th>
<th>Improving product quality</th>
<th>Minimizing the time required for converting orders into cash</th>
<th>Minimizing the total Work-In-Process (WIP)</th>
<th>Improving visibility of demand</th>
<th>Reducing costs.</th>
<th>Enhancing services</th>
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<tbody>
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<td>Reliability within six month TAM</td>
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<td>Process rate.</td>
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<td>Availability of major machines.</td>
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<td>Overall plant effectiveness</td>
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<td>Utilization of resources.</td>
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O: Strong relationship. Δ: Moderate relationship

5 Principles for Global TAM Effectiveness

Turnaround maintenance events have impact not only on the plant undergoing the TAM but also on other supply chain partners. In this section, we briefly discuss some best practices that would have a positive impact on TAM global effectiveness on the whole supply chain and relevant stakeholders rather on only the concerned plant.

5.1 Upstream plants providing raw materials
Collaboration with suppliers involves at a lower level informing suppliers ahead of time of the timing of TAM so they can plan better their production activities. At a higher level of coordination, both parties jointly deciding on the timing of TAM so that it is more convenient for both parties. In this case a clear framework for this type of collaboration is jointly developed specifying timing, roles and responsibilities and channels of communications. If the plants share similar processes, the collaboration can be extended to sharing TAM experiences and best practices. If they are heavily dependent on each other, e.g. the TAM plant is a major customer of the supplier and their plants have the same TAM frequency, they may decide to have their TAM event overlap to minimize the negative effect of the interruption on both plants.

5.2 *Downstream plants using the plant products as raw materials*

This is similar to the previous case and collaboration can benefit both parties as discussed earlier. In addition, TAM plant arrangements to satisfy downstream plant needs during TAM period should be in place and communicated to downstream partners to ensure their smooth operation.

5.3 *Vendors providing spares and long lead time items*

Good practices with spare parts and equipment vendors takes different forms. Proper selection of these partners based on long term relationships can benefit both parties:

- TAM plants recieves appropriate service from vendors in terms of high quality parts and equipment and training on new equipment ahead of installation.
- TAM plants share maintenance and equipment experience with vendors. This is crucial for vendors to develop better and more reliable equipment in the future.

5.4 *Contractors providing manpower*

Many plants are usually competing for few qualified contractors having the appropriately trained manpower. A close collaboration between plants and manpower contractors can have positive impact on the operation of all parties involved.

5.5 *Final customers buying the plants products.*

Having arrangement for an uninterrupted supply of product to customers during plant shutdown is part of good service and building lasting relationships with these customers. Plants usually build the appropriate inventory levels ahead of TAM to ensure that their key customers and unaffected by the interruption.

6 Conclusion

The paper presents a holistic view of TAM at a global level that includes all plants in the supply chain as well as supporting and service providing organizations. These parties form a network of stakeholders and supply chains with interconnected resources and benefits. In this paper the traditional TAM objectives and performance measures are taken to higher level for more integrated TAM planning and scheduling for the benefit of the whole network (supply
This view of TAM is not studied in the literature but is becoming more crucial for large size corporate originations. Possible objectives, performance measures and best practices are suggested for TAMs at the global level for more integrated planning and scheduling. Future work in this area will include further investigation on current practices and issues related to holistic view of TAM. An alternative future research area is on developing integrated planning scheduling models for TAM.

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