OPTIMIZING TURNAROUND MAINTENANCE PERFORMANCE

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Abstract: Turnarounds are the major maintenance activity for most refining, petrochemical, and chemical plants. They are costly both in terms of lost margin resulting from any plant downtime and the cost of the turnaround inspection and maintenance. The present study aimed at moving maintenance and inspection activities from a traditionally reactive or time based approach to proactive maintenance. It is characterized by the application of methods, tools, and techniques to eliminate failures, extend component life, mitigate consequences, minimize downtimes, and optimize all resources through a systematic identification and elimination of potential problems in all aspects of reliability, availability, and maintainability. The result of proactive maintenance application at Sarir refinery showed that the turnaround interval and duration could be optimized based on the risks associated with the equipment, removing items which can be implemented as a routine maintenance from turnaround work scope and application of on-line maintenance. The cost analysis and evaluation has revealed that applying turnaround performance optimization can generate increased profit. An improvement in availability was also presented.

1. INTRODUCTION

Reducing turnaround costs can also achieved by moving maintenance and inspection activities from a traditionally reactive or time based approach to proactive maintenance. The proactive methodologies for risk based inspection provide guidelines for identifying and quantifying degradation mechanisms and risk in order to help in prioritizing inspection and care actions. There are five refineries in Libya with a combined nameplate capacity of 380,000 bpd. Libya’s refineries include the Ras Lanuf export refinery, completed in 1984 and located on the Gulf of Sirte, with a crude oil refining capacity of 220,000 bpd. In northwestern Libya the 30 year old Azzawiya has a capacity of 120,000 bpd. Other refineries include the Tobruk refinery, with crude capacity of 20,000 bpd, the Brega, the oldest refinery in Libya with crude capacity of 10,000 bpd, and Sarir, with a 10,000 bpd capacity and reformer unit to produce motor gasoline. All five Libyan refineries were implementing turnarounds every two years until they moved to three years interval based on historical experience except Sarir refinery. Sarir refinery is a good example, which can be considered as a worst case study for Libyan refineries to improve turnaround performance. Although each refinery is unique because of the geographical location, refinery process configuration, crude oils delivery and products supply to the markets. The Sarir refinery can be considered as a worst case scenario compared to other Libyan refineries for a number of reasons including economical, technical, and administrative considerations. The turnaround at Sarir refinery takes 30 days and done every two years. Questions, which often posed to management in the face of turnaround performance optimization, are: (i) What are the constraints and strategies for extending the turnaround interval and reducing the turnaround duration? (ii) What is the methodology to reduce the turnaround cost?

2. METHODOLOGY

The methodology includes an assessment of current turnaround performance and benchmarking by way of key performance indicators in order to implement an improvement plan. The key drivers for assessing turnaround performance are availability, risk and cost management. Availability is a function of reliability and maintainability. Reliability is increased as the frequency of outage is reduced and time between failures or shutdowns is increased (turnaround interval). Maintainability is increased as the duration of plant,
subsystem or equipment down time is reduced (turnaround duration). The impact of turnarounds on the overall plant availability can be expressed in the equation:

\[
\text{Availability} = \frac{\text{uptime}}{\text{uptime} + \text{downtime}}
\]  

(1)

The uptime is equivalent to the turnaround interval and the downtime is equivalent to the turnaround duration. Risk management deals with the relationship of frequency of turnarounds and the risk involved. More frequent turnarounds lower the risk of forced shutdowns but increase the costs. Cost savings due to extending run lengths is often offset by an increased risk. The amount of risk involved depends on two elements namely; probability of failure and the consequences of the failure. This can be expressed as:

\[
\text{Risk} = \text{Probability of Failure} \times \text{Consequences}
\]  

(2)

Inspection influences the uncertainty of the risk associated with the equipment primarily by improving knowledge of the deterioration state and predictability of the probability of failure. Inspection is a risk management activity that may lead to risk reduction. The third key driver for assessing turnaround performance is cost management. There are four distinct groups of cost components that can influence turnaround timing decision. These are: (i) the probable cost of failure, (ii) the costs associated with planning and execution of turnaround, (iii) life cycle cost impact, and (iv) business environment related cost. Finally, internal and external benchmarking allows a company to assess where it stands competitively against various measures, including industry best practices that lead to superior turnaround performance. Turnaround performance can be benchmarked against a set of performance metrics, including turnaround interval and duration for each major process unit.

2.1 Increasing Turnaround Interval

Established practice is to use one or more of the following approaches as a basis to set the maximum intervals between inspections; (i) historical operating experience and failure data, (ii) guidelines issued by industry that recommend maximum service intervals between inspections, (iii) calculating the remaining life of the equipment based on its tolerance to deterioration, defects or damage and the rate of deterioration, and (vi) applying risk based inspection method.

2.2 Reducing Turnaround Duration

In order to achieve the aim of delivering a proposed interval without increasing the overall turnaround work scope, It would be necessary to find more effective ways to reduce the workload associated with such activities as: (i) equipment inspection and testing, (ii) repair of defects, (ii) equipment cleaning, and (vi) modifications.

2.3 Risk Based Inspection

The risk based inspection (RBI) is a technique that can be implemented to optimize turnaround performance. It uses risk as a basis for prioritizing and managing the efforts of an inspection program. In a typical operating plant, a relatively large percentage of the risk is associated with a small percentage of the equipment items. RBI permits the shift of inspection resources to provide a higher level of coverage on the high risk items and an appropriate effort on lower risk equipment.

3. DATA GATHERING AND ANALYSIS

Turnaround data (duration and interval) as well as maintenance cost (including spare parts and consumables) for the past 15 years from Sarrir refinery was collected and analyzed in this section in order to optimize maintenance performance.
3.1 Cost and Availability Determination

The fluctuation in total turnaround cost from year to year for the period from 1994 to 2005 (taking year 1994 as the base) is shown in Figure 1. There were 8 turnarounds performed since 1991 to 2005 (i.e., once every two years).

![Figure 1: Turnaround cost compared to 1994 cost](image)

Table 1 illustrates the current availability of Sarir refinery and the suggested availability for intervals of 3 and 4 years and durations of 31 and 21 days. As can be seen from this table increasing turnaround interval from 2 to 3 and 4 years, keeping the same duration of 31 days will increase availability from 95.55 to 96.82 to 97.88 respectively. The effect of reducing the turnaround duration from 31 to 21 days would result in further increased availability to 97.84 and 98.56 respectively. It can be seen from Figure 2 that the processing cost is higher during the turnaround years compared to other years.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>Interval</td>
</tr>
<tr>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>31</td>
<td>3</td>
</tr>
<tr>
<td>31</td>
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<td>21</td>
<td>3</td>
</tr>
<tr>
<td>21</td>
<td>4</td>
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</tbody>
</table>

* Current availability

Figure 3 summarizes the net profit and savings for the Sarir refinery during the turnarounds of years 2003 and 2005 in case of turnaround optimization. All Libyan refineries except Sarir extended turnaround interval from two to three years based on history.
3.2 Moving Rotary Equipment to Routine Maintenance

All redundant equipments such as pumps, boilers, gas compressors and air compressors could be removed from turnaround work scope and maintained as part of routine maintenance plan. The monitoring of all working pumps and compressors (generally all redundant equipment) in Sarrir refinery during the year 2005 demonstrated that all rotary equipment could be maintained as a routine maintenance without any threat to the operation stability.

![Graph showing annual processing costs for Sarir Refinery compared to year 1994 cost](image1)

Figure 2: Annual processing costs for Sarir Refinery compared to year 1994 cost

![Graph showing refining margin for Sarir refinery in case of turnaround optimization](image2)

Figure 3: Refining margin for Sarir refinery in case of turnaround optimization
3.3 Risk Assessment Process

The assessment of risk is based on the information which is gathered from the rates of corrosion that have been established from previous examination results, the design specification, recommendation of corrosion control regarding internal corrosion, and the operational experience of the process engineers. Input data based on descriptive information was used as the basis for the analysis of probability and consequences of failures. When the results of the risk assessment have been accepted, the correct inspection risk code is assigned to each equipment. The inspection scope for each piece of equipment is developed based on the inspection requirement highlighted during the risk assessment in order to achieve reliable results to perform on/off stream inspection. Consequences of failure is determined in terms of the toxic effects of material on human, the fire and blast effects on buildings and structures, the effects on the environment, etc. Table 2 presents the risk rating of all stationary equipment in Sarir refinery. The different colors in the table refer to the different categories of risk. There are five risk categories as follows: Very low, Low, Moderate, High, and Very high. Out of 71 vessels included in the study 39 were rated in the very low risk zone, 25 vessels in low risk zone, 5 vessels in moderate risk zone, 2 vessels in high risk zone and no vessels in very high risk zone. Vessels with asterisk (*) can be inspected and maintained during normal operation. Six vessels are in the very low risk zone, four vessels are in low risk zone and only one vessel is in moderate risk zone. The above results are in accordance with the “best in class” refineries that run their plants for more than 48 months without any outage and complete their shutdown (turnaround) in a period shorter than 23 days.

<table>
<thead>
<tr>
<th>Consequences of Failure</th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
<th>Very Low</th>
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<td>Very High</td>
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<td>High</td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Low</td>
<td>31</td>
<td>15</td>
<td>2</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Very Low</td>
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<td>1</td>
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Table 2: Risk matrix

4. CONCLUSION

The purpose of the study was to optimize turnaround performance at Sarir refinery. The goal was to move from planned maintenance to proactive maintenance by increasing turnaround duration to increase availability and lower maintenance cost. The turnaround frequencies have traditionally been time based and driven by conservative practices of regulation and industry. The first concern of the optimization process was that increasing the interval would increase probability of failure for the equipment and consequently turnaround work scope, which will increase turnaround duration. When an equipment fail, an unscheduled outage occur, which is more expensive than a scheduled outage. The cost is much higher if the outage is due to a catastrophic failure. To address this concern RBI was applied as a new approach to increase productivity and reliability, focus inspection resources, reduce inspection and maintenance costs, comply with insurance regulations and improve outage planning. All of approximately 71 vessels in 3 process units were evaluated in the Sarir refinery. The probability and consequences of failure for each equipment was determined. Then a risk matrix was developed to provide risk ranking for each
equipment. The results of risk based inspection application at Sarir refinery showed that the turnaround interval and duration could be optimized without increasing the risks associated with the equipment failure. Turnaround duration could be decreased by the application of RBI as well as by removing items from turnaround work scope to a routine maintenance plan. The other concern was that the intervals between relief valve examinations, is needed to be extended as well. An improvement process involves the application of on-line maintenance, as a new technique, would solve this problem. In addition, this problem can be solved by traditional techniques that include partial shutdown to replace valves with a standby, twinned relief systems or isolation valves in the relief stream enabling relief valve to be removed for overhaul without shutting equipment down and using rupture disk / relief valve combination to increase valves reliability. Data were collected for crude exchangers working under severe conditions through bypass of the crude feed tank. Analysis showed that turnaround interval could be extended without any fouling threat or adversity. The cost analysis and evaluation of turnaround 2003 and turnaround 2005 have revealed that increased profit can be extracted by applying turnaround performance optimization. An improvement in availability can also be attained. Industry benchmarking supports the feasibility of turnaround optimization at Sarir refinery.

4. REFERENCES