S.Shasfand, R.Jafarian Asl from Tabriz Petrochemical company

1- Summary
Tabriz petrochemical company (TPC) is a manufacturing subsidiary of NPC (National Petrochemical Company). TPC terminated 2004 with a near-zero profit.

An investigation showed that the following as root causes of unacceptable financial performance of TPC:

1. Interrupted feed,
2. Sales prices subsidized by the government,
3. Frequent shutdowns and breakdowns,
4. Production loss and different wastes

This study intends to find some solutions for the above problems. Because problems 1 and 2 are out of TPC control, the study concentrates on developing a way to resolve problems 3 and 4.

During past two years, TPC has had several accidents, fires, shutdowns and breakdowns. The project goals are assigned to reduce shutdowns and breakdowns, and to minimize loss, accidents and inventory. Achieving these goals will result in increasing plant availability, profit, productivity, reliability and quality.

The maintenance process has an extraordinary role in achieving aforesaid goals. While known as a troublesome one, it is the most important support process. Maintenance involves the largest portion of employees. It includes the second largest expenditure of the company, after feed. Maintenance is the main outsourced activity in TPC.

The symptoms of problems with the maintenance process are:

- High rate of emergency breakdowns,
- Low rate of plant availability,
- Low Mean Time Between Failure (MTBF),
- High Mean Time To Repair (MTTR),
- Excessive production loss.

This study started with the application of SWOT analysis, Maintenance Assessment and Benchmarking methods to the process. Having evaluated several petrochemical companies, two benchmarks, i.e., Chiba from Japan and Cheil from the South Korea were selected. After Gap and environmental Analysis, it was realized that three alternatives, named, BPR (Business Process Reengineering), RCM (Reliability Centered Maintenance) and TPM (Total Productive Maintenance) could solve our problems. Using Business &Operational Impacts, Risk Assessment, and Cost/Benefit Analysis for above three alternatives, TPM was evaluated as the most appropriate model for TPC.

Risks of model implementation
The risks involved in the model are mainly non-financial. They include:

- Resistance against the change inside TPC,
• Difficulty in changing organizational chart (to be approved by NPC)
• Resistance against the change by the Labor Union supported by the rigid anti-layoff regulations,
• Inconsistency of the maintenance contractor with the change,
• Possibility of mismatching with the Comprehensive IT System of TPC.

Financial Analysis

The following figures investigate the financial aspects of implementing TPM in TPC:
- The book value of equipment to be maintained: $1.2 Billion (2004)
- Model cost: About $2 Million
- Project period: 4+4 Years

Above figures can be compared to the expected benefits of the model which are:
• Reducing maintenance cost about %30 (annual benefit of $4 Million),
• Reducing shutdowns about %70 (annual benefit of $6 Million),
• Increasing production about %15 (annual benefit of $4 Million),
• ROI of the project =10 times the ROI of TPC,
• Reducing MTTR from 16 hours to 8 hours,
• Increasing MTBF from 35 days to 55 days,
• Increasing Plant Availability from %89 (2004) to %92 (2009),
• Minimizing accidents, pollution, and loss,
• Achieving the prestigious TPM International Award,
• Establishing needed infrastructure for the most advanced maintenance management model (Physical Asset Management),
• Changing maintenance department into a learning organization.

Recommendation: Balancing above risks with expected benefits, it is strongly recommended to implement TPM in TPC.

2- Background

TPC maintenance process in a glance

Maintenance is the process of ensuring that an asset’s functionality, efficiency and condition are maintained. Maintenance is a supporting process. It provides needed support for continuous production of the complex. The production, a process by itself, has a main output, i.e., products for the customers out of the company. The production process generates an inevitable byproduct also, which is equipment with low efficiency or absolutely out of service. Maintenance process receives this byproduct as input, along with some other inputs, e.g., spare parts from procurement process. The process delivers reliable and efficient equipment to the production process. In the maintenance process, the main customer and the main supplier is the production process and what processed is equipment. The maintenance process adds value to the equipment by enhancing their reliability and
efficiency. To carry out maintenance tasks, some resources such as work force, tools and maintenance devices are utilized. Maintenance is a chain of activities to maintain equipment in an acceptable condition or to change their condition from unacceptable into acceptable for further use. As understood from the above definition, the general term of maintenance covers both concepts of repair and maintenance. Equipment is repaired when they have failed or are in a near-to-failure condition; whereas, they are maintained just to increase their reliability and efficiency.

Problematic issues
The following is a list of problems easily noticed in the process.

- Complexity, frequent handoffs and excess data exchange
- Redundancy
- Irrelevant jobs attached to the process
- Tasks detached from the process
- Excessive checks and controls
- Problems with the contractual labor force
- Frustrated maintenance people
- Problems with procurement of maintenance materials
- Maintenance budgeting and cost accounting activities

The annual benefit of implementing model is forecasted to be $14 Million, while the total cost of the model will not be more than $2 Million. The time needed for achieving above objectives includes a four-year preparatory work (Exhibit -1) and another four years for implementing model (Exhibit-2).

Stakeholder analysis
Table-1 includes different stakeholders affected by the implementation of model in TPC. Each interested party has its own requirements. The positive requirements are indicated in black and the negative ones are indicated in red.

Table-1: Stakeholders’ analysis

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Overview of Business Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary-Internal</strong></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>-Omitted redundancy, irrelevant jobs, excessive handoffs</td>
</tr>
<tr>
<td></td>
<td>-Reduced stress, complexity, paper work</td>
</tr>
<tr>
<td></td>
<td>-Data availability</td>
</tr>
<tr>
<td></td>
<td>-Motivating job</td>
</tr>
<tr>
<td>Production</td>
<td>-Maximized throughput</td>
</tr>
<tr>
<td></td>
<td>-Minimized down times</td>
</tr>
<tr>
<td></td>
<td>-Excess job (Autonomous Maintenance)</td>
</tr>
<tr>
<td>TPC Management</td>
<td>-Increased profit</td>
</tr>
<tr>
<td></td>
<td>-Incremental change</td>
</tr>
<tr>
<td>Procurement</td>
<td>-Optimized inventory</td>
</tr>
<tr>
<td></td>
<td>-Lost control of purchase and inventory</td>
</tr>
<tr>
<td></td>
<td>-Reduced work load</td>
</tr>
<tr>
<td></td>
<td>-Simplified purchase process</td>
</tr>
</tbody>
</table>
Technical Service
- Reduced authority
- Reduced work load

IT Dept
- Mismatch with existing information system
- Increased work load

HSE
- No accident
- No pollution

Primary-External

Maintenance contractor
- Reduced scope of contract
- Ease of reporting
- Ease of job control

Labor Union
- Laid-off workers

NPC (Holding company)
- Increased plant availability
- Increased profit

Customers
- On-time delivery
- Product quality

Secondary-Internal

Finance
- Ease of cost accounting

Training
- Increased training
- Allocated training facilities

HRD
- Increased work load

Secondary-External

Society
- No pollution
- Increased unemployment

Suppliers
- Direct relations with the end user
- Less purchase

3-Finding some benchmarks

According to the following reasons, two petrochemical companies, a Japanese company called IDEMITSU-Chiba and a South Korean company named Cheil, were selected as appropriate benchmarks to TPC:
1) Benchmark companies have been visited.
2) Their core business, production of polymers, is the same as that of TPC.
3) They are Asian top level competitive petrochemical companies.
4) Both companies have been celebrated by TPM (Total Productive Maintenance) international award for the improvement of their maintenance processes.

A brief introduction to Tabriz Petrochemical Company (TPC)(7)

- Date established: 1988
- Number of employees: more than 2000 (2005)
- Revenue from sales: $232 mm (2004)
- Core purpose: Development for better life
- Core values: Endeavor, Creativity, and Excellence
- Vision: 3Z (Zero defect, Zero pollution, Zero accident)
- Mission: The main concerns are safety, personal and environmental protection, quality of products and cost reduction
IDEMITSU-Chiba Petrochemical Company (1)

The Japanese company Chiba was established in 1964 with a capital of $20 Million. Its annual sale is $ 2.6 Billion (1998) while employs 2240 people (Petrochemical & Refinery). Chiba produces chemicals and polymers.

Mission

The company's mission includes:

- Minimizing costs,
- Maximizing plant performance,
- Boosting profit,
- Maintaining safety, ecology and reliability,
- Providing continuous improvement,
- Transferring-in knowledge and best practices.

Cheil Petrochemical Company (5)

Cheil, the chemical subsidiary of Samsung Co, completed the Yeosu Plant in 1989. Selling products with the brand name of “Starex”, Yeosu Plant has an advanced, up to date, and fully automated production system. It has computerized the whole production procedures from order input to shipment through Enterprise Resource Planning (ERP). Furthermore, it is supported by the R&D effort of Cheil Industries.

Vision and Mission (5)

To become the most competitive plant in 21st century

Motto: WIN 350

Vision:

- World Best Plant In New Millennium,
- Reducing manufacturing costs by 30 billion Won,
- Constructing the most innovative Logistics Management System,
- On-time delivery yield: 90%
- Reducing the current inventory down to 50%
- Zero Defected Products, Zero accident

4-Identifying the gaps between TPC maintenance system and the benchmarks

Comparing TPC maintenance system and the selected benchmarks, some distinguished gaps are identified. They can be analyzed to form a model for improving the existing maintenance process of TPC.

Gap1- Position in Maintenance Management Excellence Model

The existing system of TPC maintenance uses off-line condition monitoring, manual preventive maintenance, particles-in-oil analysis, cathodic protection, thickness measurement, calibration and corrective actions in a functional manner.
Our benchmarks (Chiba and Cheil petrochemical companies) and TPC position in the Maintenance Management Pyramid of Excellence are shown in Figure-1. Chiba is located in the top layer of the pyramid (Quantum Leaps). The proofs are winning the "Award for TPM Excellence" in 1999, reengineering the maintenance process, implementing concurrent engineering, focusing on people involvement and empowerment by enhancing team working, establishing Suggestion system and Total Quality Management (TQM). On the other hand, Cheil is situated in the Continuous Improvement layer of the pyramid. The evidences are winning the "Award for TPM Excellence" in 2001 and starting to implement 6-sigma, Suggestion System, and TQM.
Compared to its benchmarks, TPC occupies a much lower position in the Maintenance Management Excellence model.

**Gap 2- Adopted maintenance strategies and tactics**

There is a variety of maintenance strategies and tactics which have been devised and evolved step by step; so that some strategies are considered advanced (such as RCM and TPM) and some are evaluated as preliminary (such as Reactive Maintenance). Therefore, how different strategies contribute in a maintenance system is an indicator of the degree of advancement of the system.

The maintenance strategies tactics used either in TPC or the benchmarks (Chiba and Cheil) are almost the same. Reactive Maintenance (Break-down Maintenance), Preventive Maintenance (PM), Predictive Maintenance (PDM), Corrective Actions (a Proactive Maintenance tactic), and Maintenance Prevention (MP or Design Modification) are maintenance strategies and tactics used in TPC, Chiba and Cheil. However, the distribution of maintenance strategies and tactics adopted by TPC is far different from the benchmark companies.

Figure-2 compares the three companies for the distribution of maintenance strategies in each. The chart shows that TPC mainly uses Reactive and Preventive tactics (%80) while the benchmarks mainly use Predictive tactics and focus on Proactive and Maintenance Prevention.

![Tactics comparison](image)

*Figure-2: A comparison of TPC, Chiba and Cheil for their adopted maintenance strategies and tactics (1),(6),(7)(4)*
Gap 3- Human resource productivity

Human resource productivity is a recognized indicator for organizational performance. It can be used for comparing a company with its past or goals. Also, it can be used for comparing two or more organizations. Table-2 indicates that the productivity of people in TPC and its maintenance dept. is low compared to our benchmarks. One important reason for such a result in TPC maintenance is related to these facts that in TPC people have been restricted to their functional boundaries, while in benchmark companies people are boundary-less and multi functional. The other reason is that in benchmark companies the autonomous maintenance including simple maintenance jobs are done by operation people, while in TPC all maintenance activities are carried out by maintenance people which are as a result of traditional management system.

Table-2 indicates that the productivity of people either in TPC or its maintenance department is low compared to the benchmarks.

Table-2: A comparison of TPC, Chiba and Cheil for the human resource productivity (1),(5),(7)

<table>
<thead>
<tr>
<th></th>
<th>Total Products (ton/year)</th>
<th>Total employees</th>
<th>No. of Maintenance employees</th>
<th>Product per capita</th>
<th>Maintenance people over Total employees (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiba</td>
<td>1,681,000</td>
<td>1020</td>
<td>214</td>
<td>1648</td>
<td>%21</td>
</tr>
<tr>
<td>Cheil</td>
<td>670,000</td>
<td>710</td>
<td>202</td>
<td>944</td>
<td>%28</td>
</tr>
<tr>
<td>TPC</td>
<td>684,000</td>
<td>2,000</td>
<td>1,130</td>
<td>342</td>
<td>%56</td>
</tr>
</tbody>
</table>

Gap 4- Sub-optimization by different functions

In the benchmark companies, the top managers have defined overall performance measures for the whole company to avoid sub-optimization by different functions which results in conflicts between them and decreased productivity. Compared to the benchmarks, TPC top management has not determined overall performance measure to coordinate and direct the activities of different functions. That is why each function only focuses on optimizing its relevant performance, regardless of the adversary effect it may have on the overall performance of the company.

The contradicting goals of different functions result in increased organizational conflicts. Figure-3 names the goals of different processes in every organization.
Contemporary management systems include a performance measurement subsystem to monitor and control their processes and activities. Maintenance process has specified performance indicators. The most important maintenance performance indexes including MTBF (Mean Time Between Failures) MTTR (Mean Time To Repair), Equipment Reliability and Plant Availability are showed in Figure-4.

The benchmark companies continuously measure all above indexes to make appropriate maintenance decisions, whereas the only index measured by TPC is Plant Availability.

Plant Availability is defined as the ratio of the production days to 365. A Plant Availability of 100% indicates that the plant has been running throughout the year, without any interrupted production. This ratio is %93.5, %91, and %87 for Chiba, Cheil and TPC respectively.

In addition, overhauls are scheduled once in 3 years in TPC, while the same interval is 5 years for the benchmark companies. The time between two consequent overhauls directly affects Plant Availability, so that the longer interval, the more Plant Availability.
Gap 6- Organizational structure

An organizational can be structured in different ways. The traditional structure is shaped around functions (departments), while new structure matches processes flow in the organization. TPC has a functional organization, whereas both benchmark companies are process-oriented organizations. For example, in the benchmark companies’ quality control, purchasing, material control, and safety activities are included in the maintenance, while in TPC such activities are concentrated in individual departments established to carry out each function.

Gap 7- Maintenance cost accounting system

In traditional maintenance systems, cost of maintaining a piece of equipment is not calculated and analyzed, whereas in advanced systems Life Cycle Cost of each piece is a major criterion for making decisions on it, such as purchasing, maintaining and discarding. TPC uses the traditional total cost accounting method without considering the cost of each piece of equipment. In TPC, cost of individual pieces of equipment is not analyzed for making decision whether to preserve or replace them. In both benchmark companies cost of each piece of equipment is identified and evaluated according to the Life Cycle Cost (LCC) method.

5-Alternatives

The purpose of this project is identifying the most suitable maintenance management model for TPC. Consequently, different strategies and models of maintenance should be studied to select the most appropriate one.
In this section different alternative solutions (Business Process Reengineering (BPR), Reliability Centered Maintenance (RCM), and Total Productive Maintenance (TPM)) are briefly introduced and compared.

6-Conclusions & Recommendations

Conclusions
The current situation (status quo) will not meet the objectives and vision of TPC. Table-3 summarizes the business & operational impact, project risk assessment and cost/benefit analysis of different alternatives.

Table-3: Conclusions (8)

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Business &amp; Operational Impact</th>
<th>Project Risk Assessment</th>
<th>Cost/Benefit Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Present Value of total Benefits</td>
<td>Present value of total costs</td>
</tr>
<tr>
<td>BPR</td>
<td>204</td>
<td>22.5</td>
<td>$29,610,800.02</td>
</tr>
<tr>
<td>RCM</td>
<td>174</td>
<td>9.5</td>
<td>$8,327,060.78</td>
</tr>
<tr>
<td>TPM</td>
<td>194</td>
<td>8.5</td>
<td>$8,141,389.35</td>
</tr>
</tbody>
</table>

Based on the above information and for maximizing the effectiveness and efficiency with minimizing risk and cost, and considering current governmental basis of TPC and with reference to the cultural issues, TPM seems to be an appropriate choice.

Recommendations

- Convincing the top management for creating sense of urgency regarding the vitality of project execution
- Negotiation with NPC management to change organizational chart
- Holding training and seminars for developing cultural changes
- Forming a steering committee
- Establishing TPM executive organization
- Hiring a qualified TPM consultant
- Celebrating short-wins
- Appropriate rewarding system

7-Implementation strategy

Preparatory phase for implementing TPM at TPC
Exhibit -1 indicates the proposed schedule of the preparatory activities at TPC. The preparatory phase of implementing TPM at TPC involves execution of two major projects. They are:
- Computerized Maintenance Management System (CMMS),
- On-line Condition Monitoring.
Establishment of CMMS requires that some prerequisite projects be accomplished to provide needed infrastructures for implementing CMMS. These projects will be explained later (See Prerequisite projects as below).

**Major project 1: CMMS**

CMMS stands for Computerized Maintenance Management. Basically, CMMS is a computerized solution to managing the Maintenance Management needs of manufacturing facilities. TPC is implementing a CMMS project with a progress of 90% at the end of August, 2005.

**Prerequisite projects**

To implement CMMS, TPC had to define and execute some prerequisite to prepare needed infrastructures. These were:

- Project 1: Identifying the criticality of equipment.
- Project 2: Mechanization of Technical Archive,
- Project 3: Equipment Management Information System (EIMS),

**Pre-project 1: Identifying the criticality of equipment**

This project was started in Jan. 2005 and finished after three months. For executing the project a team including representatives from Production, Maintenance, and Technical service Depts. was formed. The main duty of this team was classifying rotary equipment to identify the most critical equipment of TPC plant.

The team could identify the most critical rotating machines among 5240 ones. The result was classifying 31 machines as the most critical rotary equipment.

**Pre-project 2: Mechanization of Technical Archive**

TPC has a Technical Archive (Technical Documents Center). The whole technical information was gathered in more than 1,300,000 paper documents. The goal of the project was changing paper documents to computer files. It achieved by sorting, classifying, and scanning the paper documents. The computer files now are included in the Comprehensive Information System (CIS) of TPC which is under the control of IMS department.

The pre-project 2 started in Jan. 2005 and finished in less than 6 months. Execution of the pre-project 1 enabled TPC to step towards the pre-project 3.

**Pre-project 3: Equipment Information Management System (EIMS)**

EIMS is a subsystem of CMMS. TPC expects to establish the system in 6 months as a prerequisite to implement CMMS. The following is a short list of activities included in the Pre-project 2:

- Gathering all technical documents related to the whole installed equipment (28817 pieces of equipment);
- Identifying different types of equipment and categorizing them;
- Allocating a code to every production (and infrastructural) system and subsystem and every piece of equipment;
- Designing required forms to record the gathered information;
• Recording information on the designed forms;
• Designing a computer software to mechanize the information recorded on the forms;
• Gathering comprehensive procurement, financial, operational, calibration, inspection, maintenance and safety information on each piece of equipment;
• Quality control of information before feeding to computer;
• Feeding information;
• Tentative use of the system;
• Checking the results and debugging the system.

Major project 2: On-line Condition Monitoring System

Having classified some rotary machines as most critical ones (Pre-project 3), bidding documents were prepared and a German-Danish company named "B&K Vibro" was selected as project contractor on April 2005. Scope of contract includes design, procurement, installation, commissioning and training of the system. Contract period is 18 months and the existing progress level is about %40.

In this system special sensor for measuring speed and/or acceleration and/or displacement will be installed in the most critical machines of TPC. The measured signals will be received by Data Acquisition Units of the system and will be continuously monitored by related trained specialists.

8-Appendixes

• Exhibit 1 - Schedule of preparatory work
• Exhibit 2- Master plan for implementing the model

9-References

1) IDEMITSU Chiba presentation, October 14, 2003
2) www.idemitsu.co.jp
3) Physical Asset Management Certificate Program, University of Toronto Professional Development Centre, Iran 2004
4) CAREY KEVIN, www.fedmonitor.com
5) www.cheilindustreis.com
6) Cheil Maintenance Documents
7) TPC documents and reports
8) S. Shasfand/R. jafarianAsl/M. Nezafati/S. K. Sadreddini, Businesscase, Developing Maintenance management Model, June 2005