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Benchmarking Key Performance Indicators and Metrics on Inventory Turnaround Practices in Middle East Petroleum Projects

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Abstract

Benchmarking is a quality management practice that enhances organizational self-assessment and overall performance. The best practices in the industry are usually used as a model by organizations for staying competitive in the market, while focusing on improving their own performance. Benchmarking practices significantly contribute to the quality of information in the petroleum industry. Inventory metrics are indicators one can benchmark giving an insight into how your operations performance is doing over time and against the industry average. This study proposes a benchmarking model to be used as a yardstick for effective inventory management, with an emphasis on maintenance, repair, and operations (MRO); materials management; and test and inspection (T&I), or turnaround practices. The research methodology identifies the metrics and Key Performance Indicators (KPIs) that should be benchmarked against the Industry. Benchmarking parameters from the best in the industry are analyzed and presented to enhance the performance of an organization and achieve organizational excellence with increasing inclinations towards quality control and management. Although the application of this model is generic to Oil & Gas Industry globally, it is more concentrated to organizations and Petroleum Projects in the Middle East.

Keywords

Inventory management, Benchmarking, Petroleum industry

1. Introduction to Benchmarking

Lessons learned from the best practices organizations have shown systemic project failure by many organizations to achieve their objectives while pointing to the best-in-class companies or projects that have a competitive advantage in terms of capital delivery. Peter Drucker once said, “You can’t manage what you can’t measure.” Benchmarking is a quality management practice that facilitates organizational improvement

by measuring and recording performance levels and best practices. Organizations should continually compare their performance against the strongest competitors in order to improve.

The Construction Industry Institute (CII) best practice definition for benchmarking is "The systematic process of measuring an organization's performance against recognized leaders for the purpose of determining best practices that lead to superior performance when adapted and utilized." (CII, 2020)
The AACE defines benchmarking as "A measurement and analysis process that compares practices, processes, and relevant measures to those of a selected basis of comparison (i.e., the benchmark) to improve performance. The comparison basis includes internal or external competitive or best practices, processes, or measures." (AACE, 2020)

Independent Project Analysis (IPA), the world's leading benchmarking, research, and consulting organization with a proprietary database that includes thousands of site-based projects around the world, states that "Benchmarking is the first step for capital project systems to achieve predictability, drive competitiveness, and enable success." (IPA, 2020)

A Benchmarking Study is performed on a project to compare that project's cost, schedule, scope, material requirements, best practices, operability, and other parameters to similar projects within its own organization as well as within the industry. Benchmarking can be internal, external, or both. Internal Benchmarking looks at the performance of a project or entity within an organization over time while External Benchmarking is an analysis of the performance of a project or entity as compared to others in the same industry in order to identify the shortfall and areas of improvement. Benchmarking captures the information from both external and internal practices and performance to drive continuous improvement.

1.1. Internal vs External Benchmarking

Internal benchmarking is when organizations compare their systems and processes with the best performers within their organization. Internal benchmarking requires systematic collection and analysis of an organization's historical project data. A number of companies keep historical data with the goal of continuous improvement by benchmarking against the historical data. Lance Stephenson argues that benchmarking is more than the collection of historical data and that many organizations confuse it as benchmarking. Historical data is just one element of an overall benchmarking process. Competitive benchmarking relies more on contemporaneous data rather than historical data (Stephenson and Bredehoeft, 2020). To make the internal benchmarking effective, aggressive targets must be set and the benchmarking data needs to be continually updated as projects are completed.

External benchmarking is when organizations compare their systems and processes with the best performers outside the organization. External benchmarking should be conducted by independent outside entities or consultants with no bias on the benchmarking outcome. A key factor to consider is which Key Performance Indicators (KPIs) will be selected for comparison. The analysis should be performed at the appropriate stage of the project, comparing key parameters of the project with an external industry-wide database (Stephenson and Bredehoeft, 2020).

An organization should conduct both internal and external benchmarks for continuous improvement opportunities to effectively identify and prioritize key improvements.

1.2. Benchmarking Stages

Benchmarking can be viewed as being useful at three key stages: at the project's conceptual stage as a pacesetter review, at the end of front-end engineering design as a readiness review, and finally at completion as project close-out and operability review. Required metrics and data need to be collected for the benchmarking effort at any given stage of a project. It is noted that project stages may vary depending on type of project. For example, capital projects have much longer cycle time than turnaround projects, yet both go through the conceptual planning, front-end design, and actual execution (including testing and commissioning).

1.3. Benchmarking Methodology

In today's dynamic business environment an end-to-end methodology helps organizations plan and execute both internal, external and functional benchmarking studies that deliver actionable improvement recommendations (HBSC). Charles Burke, a benchmarking expert provided ten steps as benchmarking methodology. These include (Burke, 2020):

Step 1-Determine processes to be benchmarked
Step 2-Determine organizations to be benchmarked
Step 3-Gather data
Step 4-Analyze for gaps
Step 5-Determine future trends
Step 6-Reveal results and sell the process
Step 7-Achieve consensus on revised goals
Step 8-Establish action plans
Step 9-Implement plans and monitor results
Step 10-Recalibrate benchmarks

The benchmarking process may differ from organization to organization, or type of project or product. Nevertheless, building upon Charles Burke research, this paper presents a 6 step methodology for benchmarking, as shown in Figure 1 below, can be developed to focus the benchmarking for effective results:

Figure 1 Benchmarking Methodology

The first step in the benchmarking methodology is to set the benchmarking strategic objectives for both internal and external benchmarking. This includes setting a detailed plan with timing and identify the available resources for data collection and analysis. Also during this step decide which internal/external projects and organizations as peer groups to select for comparisons. It is important to set your goals for the metrics/KPIs you are measuring.

Next step is to identify which processes and KPI's to evaluate. The KPIs and Metrics for inventory benchmarking maybe different than for example turnaround, etc. More is described under Inventory Metrics Management section below.

The Data Collection is at the heart of the benchmarking methodology. This includes gathering the necessary data, including questionnaire forms and face-to-face interviews with key stakeholders. The data gathered from the input forms and stakeholders interview are essential to do the benchmarking analysis and reports. Therefore, the organization must pay special attention on who is assigned to fill out the questionnaire and participate in the interviews. It should be the stakeholders who are totally familiar with the inventory process.

The next step is the actual analysis of the data and the comparison with both internal and external benchmarking organizations and/or projects. This step is usually conducted by Subject Matter Expert (SME), most effectively by an outside specialty benchmarking consultant. This step includes identifying all the GAPS where the biggest opportunities for improvement are in the metrics that can impact the Strategic Objectives. There may be several interactions with the stakeholders to complete any clarifications before the final report is issued.

Preparing a thorough benchmarking report that identifies strength and weakness of the organization in respect to the selected KPIs is the next step. It is a good practice to prepare a draft report and to share it with key stakeholders before the issuance of the formal report. Benchmarking report should identify areas of improvement along with an improvement plan that includes the recommended tasks, steps, and timing for improvements.

The final step in the benchmarking methodology is the execution of the improvement plan. Benchmarking is an ongoing continuous improvement process. It is important to continuously measure progress in line with your strategic objectives.

1.4. Benchmarking Normalization

One of the challenges of benchmarking is how to address questions such as: "our organization is unique, you cannot compare us with such as such", or "the data gathered from projects in North America or Europe does not apply to the projects in the Middle East", or "we have special situation with material logistics, warehousing issues, weather, etc., that cannot be compared with other projects". Care must be taken to compare similar organizations or projects with similar ones, and include data from the same region and same industry. Never-the-less benchmarking data and report must be normalized to account for large variabilities such as different productivity factors, material shipping logistics, local laws in terms of local share of vendors and material, weather factors, project execution methods, etc. The benchmark report and analysis shall clearly state the normalization process used, including (but not limited to) timeline, location, year of funding, productivity factors, project execution methodology, specific owner requirements, safety, and standards requirements. Figure 2 below shows the Benchmarking Normalization by Region and Best-In-Class.

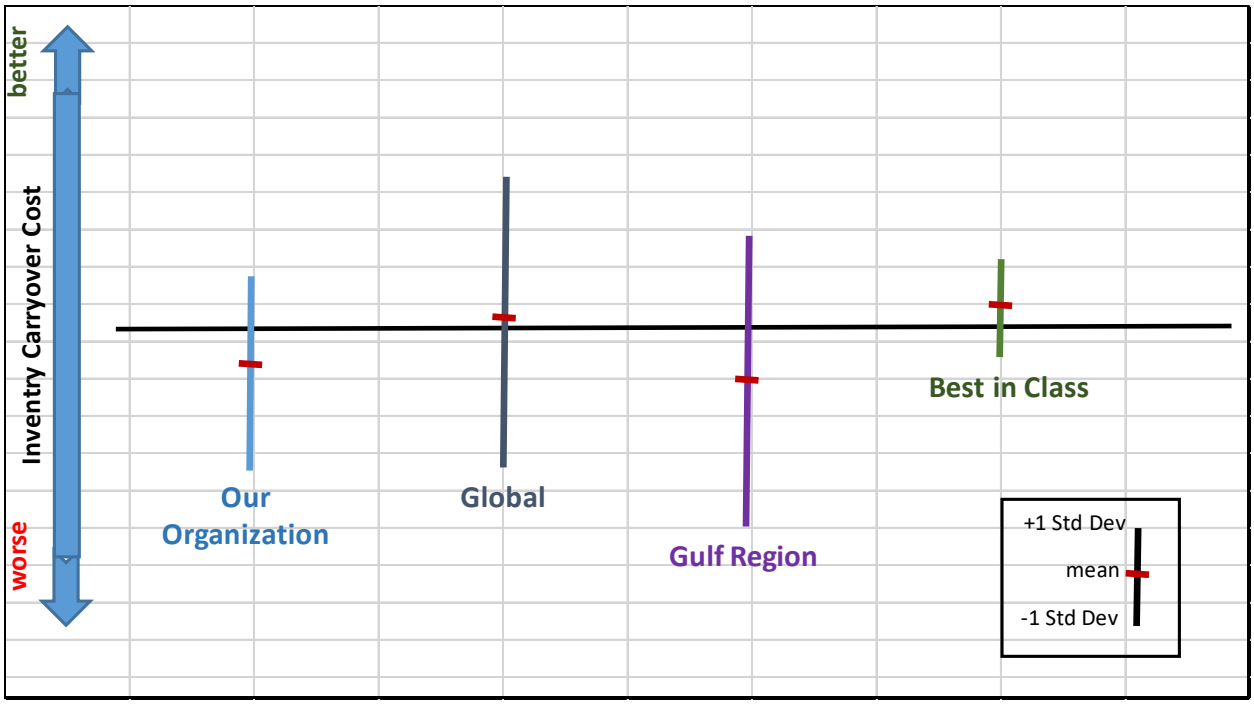

Figure 2 Example of Benchmarking Normalization by Region and Best-In-Class

1.5. Benchmarking Drivers on Oil & Gas Capital Projects

The oil and gas industry has taken significant steps to improve efficiency. They continue to explore areas of opportunity to come up with new initiatives and be able to compare to others. There are certain drivers that are common to most Oil & Gas organizations in particular to capital projects. These include:

a. Front-end Loading
b. Value Improvement Practices
c. Project Management Practices;
d. Contracting Strategies;
e. Target-Setting Deliverables (where applicable)
f. Team Development Index;
g. Estimating / Planning for Control;
h. Execution Strategy;
i. Market Conditions Impact;
j. Key Quantities.

2. Benchmarking Inventory Metrics Management

The key to benchmarking success is selection of the right metrics or parameters, as they play an important role in qualitative best practices. The metrics facilitate the "gap analyses" and identify areas that need improvement. Many planning KPIs are available, but users must identify indicators that are important in meeting the benchmarking objectives. In general, supply chain management KPIs should include (Vipin, 2010):

The industry metrics used for this model include:

a. On-Time Delivery
b. Cycle Time
c. Average Days Inventory Level
d. Inventory Carrying Cost

e. Inventory Turnover, or the number of times inventory is turned over in a given period
f. Order Fill Rate

On-Time Delivery is the final shipping and delivery date to the customer on the date that was originally agreed.
Cycle Time is the actual ship date minus the purchase order date.
Average Days Inventory Level is how long it takes to turn the inventory into sale. It is a measure of inventory management efficiency,
Inventory Carrying Cost is the cost of carrying inventory usually in the form of percentage that represents the carrying cost divided by the overall cost.
Inventory Turnover is the number of times inventory used within a period of time. Ideally, you want to increase your inventory turnover and reduce your holding of inventory.
Order Fill Rate is the percentage of customer orders that are fulfilled by available stock of inventory. It is also an indicative of customer satisfaction as it is closely tied to how many orders are completed by the available inventory stock.

Other related KPIs may also be included as well. Having a strong inventory optimization program can result in lower inventories and carrying costs and each year they continue to look for ways to improve performance and control growth, while still meeting the demands of their customers.

2.1 Benefits of Successful Supply Chain Benchmarking

Supply Chain benchmarking provides a true view of the supply chain performance compared with similar operations and helps to identify and set realistic objectives. It can also be used to set a baseline for continuous improvement and highlights gaps separating the operational performance from that of best-in-class supply chains (Rob O'Byrne 2016)

a. Performance improvements
b. Interdependencies and relationships between key performance indicators (KPIs)
c. Better business tradeoffs
d. Opportunities for cross-industry best practices
e. Baseline information for goal setting, prioritization, and ongoing performance measurements

2.2 Benchmarking Test & Inspection and Plant Turnarounds

A plant turnaround is an event during which one or more processing units are temporarily removed from operation. Different industries use different terminologies to connote this concept. Some use the term "turnaround," others use "shutdown," while still others use the term "outage" and some use "Testing & Inspection" (T&I). During a scheduled shutdown, time is of the essence. Having the replacement or new equipment and material in time is a key ingredient to make the turnaround a success as there is a huge loss of profit for each day of downtime.

Turnaround benchmarking facilitates the comparison of the turnarounds to Industry norms. Key parameters to compare may consist of planned and actual cost, scope, productivity, duration, labor hours, safety, and operability. There are generally two types of turnarounds: Planned and Unplanned. Planned turnaround includes routine unit shutdowns for maintenance which may be scheduled months or even years in advance. This facilitates the maintenance planners to order/reserve the replacement equipment and material months in advance so that it is ordered and expedited to arrive on time. Some of the larger process equipment, such as compressors or exchangers, require engineering work and vendor data far before the actual manufacturing. Unplanned turnarounds is when the unit or plant is temporarily shut down due to equipment malfunction or other reasons (Shawn Hansen and Brett Schroeder, 2016)

3. Supply Chain Risk

The uncertainty between supply and demand volumes necessitates the presence of inventory. The need for inventory formation and maintenance reduces by itself if there is a perfect synchronization in the productive chain. In other words, inventory acts as a buffer for catering uncertainties between the supply and demand networks. The possible incapacities are managed and compensated for by the inventory and results in

competitive synchronization in the productive chains. The interconnection between supply and demand networks may sometimes lead to dicey environments.

Bringing the right supplies to the respective demands contains risk. It involves several influencing factors that can disrupt the supply or demand of a system, which were not envisioned when starting manufacturing or transport of the materials. A natural disaster such as COVID-19 is an appropriate example. The supply chain risk may lead to distracted efforts and loss of confidence among the stakeholders. Information sharing brings all the supply chain partners on the same page by securing information accessibility. It also facilitates in minimizing risk and retaining confidence, leading towards practical, efficient, and focused efforts of the involved partners in supply chain operations. The importance of data sharing has always been eminent in the logistics and transport service industry. The logistics system gets strengthened by the creation of distributed databases in the common industrial organizations. Moreover, the process of decision-making among stakeholders improves due to the availability of consistent, valuable information.

4. Benchmarking: A Practical Self-Assessment Tool

The best practices in the industry, supply chain networks, and inventories are imitated by the logistics systems to stay competitive in the market by improving their own performance. Inventory systems should closely monitor and adopt new technologies, best practices, and changes in the environment pertaining to a specific industry as well as other industries, for updating their own system in time. It leads to a productive and viable presence of the logistics network in the marketplace. Benchmarking is one of the self-assessment and self-improvement practices (Taylor, 1998). Logistics performance can be enhanced by incorporating this tool in an inventory system. The extent of improvement would be the organizational core competencies in general. Benchmarking tools can be useful for the logistics systems if the primary capabilities and proficiencies of competitors in the market are well understood and analyzed, otherwise it would not have any significant effects (Drew, 1997). Vishal Gaur, M. L. Fisher, and A. Raman carried their research on inventory turnover and proposed a metric model which can be applied to managerial decision making and benchmarking (Gaur et al., 2005).

Benchmarking practices have been considered as a quality management technique (Rao et al., 1999). The unforeseen rapid pace in global development, owing to progress in technological and information systems, has resulted in enhanced competition among industries and respective logistics systems. All these factors expedite the implementation of benchmarking practices. Its implementation outcomes include, but are not limited to, the prediction of the emergence of new technologies, firms having more vivid tools for monitoring variations in the logistics system, and observation of novel management practices and their implementation. Benchmarking can be divided into three categories: services/products benchmarking for comparing the services and/or products in an industry; process benchmarking refers to the assessment and comparison of various organizational processes, practices, operations, and routines; and strategic benchmarking deals with the comparison of managerial best practices, organizational structures, and corporate strategies (Main, 1992; Drew, 1997). Benchmarking, irrespective of its type and scope, is used for improving the performance of a logistics system.

The goal of benchmarking includes understanding how others are performing better in a specific field, so their practice can be imitated or even improved for optimum outcomes. The present study visualizes the importance of inventory benchmarking in the petroleum industry and proposes a set of benchmarking practices in terms of metrics. These benchmarking procedures provide insight into petroleum industry inventories, resulting in overall inventory process improvement at the least, and leading towards excellence in performance.. For further details about benchmarking practices in inventory systems, the author refers to previously published investigations (Ma et al., 2004; Disney et al., 2006; Putkivaara, 2020; Ho, 2020; Verellen et al., 2019; Alves et al., 2018).

The projected benchmarking practices along with their respective metrics are listed in Table 1. The efficiency of inventory plays a significant role in the overall performance of the petroleum industry. The robustness of an inventory system is characterized by superior materials management and optimization. Best practices from the petroleum industry inventory have been gathered for benchmarking. It includes the total level of inventory, in terms of USD. The volume of inventory would be the first step in the benchmarking process. The level of inventory may change from a small unit to the gigantic multiple units', under the umbrella of

large petroleum companies. It may act as a first parameter of comparison for inventory in petroleum industry. It may then be followed by other inventory parameters. The number of inventory items count would shed some light on the volume of transactions and activity in the industry. Inventory systems can be characterized, compared, and analyzed in terms of material count. Another parameter for comparing inventory systems is the number of beneficiaries. The number of total organizations and entities being served by the inventory also compares and benchmarks the system. Inventories with similar number of served entities can benchmark and assess their outcomes against other competitors. It would help them to analyze their own position in the marketplace and aid them in improving their own performance to have better competitive outcomes.

The number of personnel working on an inventory is another factor for comparison. The headcount of the inventory management, operations, and optimization workforce may be used as a yardstick to understand the market competition on equally-level ground. This benchmarking practice may yield data about the common industries with nearly equal manpower, so that their performance can be juxtaposed for improvement purposes.

Table 1 - Benchmarking Metrics

Benchmarking KPI		Metrics		Description
1	Inventory Optimization and Materials Management Practices	1.1	Total Inventory Level	Value in USD
		1.2	Number of Items	Count of materials
		1.3	Number of Total Organizations Served by Inventory	Count of entities
		1.4	Number of Materials Management Workforce	Headcount working in managing and optimizing the inventory
		1.5	Inventory Quality Ratio (IQR)	IQR = (Active Inventory / Total Inventory) * 100 Active: 0-2 years // Slow moving: 2-5 years // None Moving: < 5 years (Critical and insurance-type materials included)
		1.6	Value of Inventory Managed by Vendors	Value in USD
		1.7	Top Level Entity Responsible for Inventory	Corporate committee
		1.8	Type of Reporting Mechanism	Report and dashboard, and how frequently it gets updated
		1.9	Inventory Key Performance Indicators (KPIs)	List of KPIs and calculation formula
		1.10	Inventory Fill Rate	Fill rate % = (Fulfilled items / total reservations (Fulfilled + Non-fulfilled)*100)
		1.11	Revalidation of Critical Quantity Materials	Number of years for revalidation cycle
		1.12	Stock Coverage	Indicate the stock coverage in months which means how long the on-hand stock will last at the current forecast or consumption rates
2	Materials Write-Off	2.1	Annual Average Materials Write-Off from Inventory	Value in USD
		2.2	Years of Stored Common Spare Parts	Number of years
		2.3	Years of Stored Common General Supplies	Number of years
		2.4	Years of Stored Unique Materials	Number of years

3	Turnaround and Shutdown	3.1	Annual Value of Inventory Materials in Support of Turnaround and Shutdown Activities	Annual value in USD of inventory materials used for turnaround, shutdown, and outage activities
		3.2	Materials Return after Turnaround Completion	% of materials return from turnaround compared to original scope of materials requirements
4	Workforce Development	4.1	Inventory Training and Certificates	Type of certified and training programs on inventory and materials management

The inventory with the least number of workforce headcount and enhanced performance would be considered as the best competitor and their case studies would reveal the outcome of their improved performance per head. This practice can then be imitated for performance improvement and can be further enhanced for achieving excellence in a particular field. Another benchmarking practice is proposed based on inventory quality ratio (IQR), which helps in effectively analyzing the inventory. It is a comprehensive approach which is used for evaluating the current value versus future demand values. It indicates how many inventories are having active movements (0-2 years), which inventory stocks are slow moving (2-5 years), and which parts are non-moving (< 5 years). It also includes the critical parts used for breakdown maintenance purposes, installation reasons, and insurance-type materials. Based on this inventory performance tool, inventories can be benchmarked for execution improvements.

Using vendors for managing material stocks is a common practice in inventory. The value of inventory being managed by vendors (in terms of USD) can be used as a benchmarking tool. The role of top management is crucial in terms of decision making, managing, and optimizing the inventory operations. The number of top-level corporate committee members responsible for inventory is another yardstick for measuring performance and analyzing the respective comparisons among different inventory systems present in the market. It is because this tool indicates the level of responsibility being assigned to the inventory. Furthermore, the way in which inventory data is updated and reported (and its frequency) is also an important feature of an inventory system. The type of reporting mechanism can be used as another benchmarking practice for comparison. The inventories with similar inventory dashboards updating frequency and reporting mechanisms can be compared on similar grounds, and their performance can be evaluated.

The performance of involved manpower is evaluated by Key Performance Indicators (KPIs). The inventories with similar lists of indicators and calculation formulas can be juxtaposed for evaluating overall performance. The KPIs tool can be used as a rule of thumb for comparison, as these indicators are the incentivized objectives of the workforce. Inventories with similar KPIs for similar categories of involved manpower can be compared for analyzing this benchmarking practice. Another way to understand the inventory performance by comparison is inventory fill rate. It is actually a comparison between fulfilled items and total reservations in an inventory. The performance of an inventory can be studied in fill rate terms so that efficiency of the system can be evaluated. In addition, significant materials are assigned critical quantities in inventory for important industrial operations. Inventory management and optimization practices also include the revalidation of these critical quantity materials. The definition of the time span (in number of years) for revalidation cycle is important for catering the ongoing changes in the industry. It can be used as one of the benchmarking tools for self-assessment of an inventory system. The indication of stock coverage is another essential factor for inventory. It estimates the utility time period (in months) of the existing material in the inventory, based on the available data of consumption rates or the current forecast. The comparison in terms of stock coverage with the competitor's inventory systems would enable self-appraisal and improvement, which may lead towards excellence for optimized industrial operations. The information of stock coverage can be used as an efficient benchmarking tool, as it reveals the right amount of time for a specific material to remain in the inventory. It would enable the inventory managers and operators to utilize the space effectively for improved overall performance.

The inventory materials which no longer possess any value are formally recognized as materials write-off. It refers to the material which have reduced or zero value. The inventory system can be benchmarked based on material write-off information. The data of annual average materials write-off from inventory, in terms of USD, would aid the inventory managers in analyzing performance. Further, the comparative evaluation with other competitor inventories in the market would serve as an improvement tool. Other valuable information

involves data about time period (in number of years) for the stored common spare parts, common general supplies, and unique materials in the inventory systems. This data from the competitor inventories would aid the top-management to self-assess the performance of their own inventory. It would serve as a benchmarking tool for understanding where a particular inventory is standing as compared to the market, so that improvement practices may be focused in relevant areas for overall progress and development of inventory, as well as industry as a whole. This information would enable the inventory managers to utilize space in an efficient manner for optimized outcomes.

Turnaround and shutdown of industries involve a considerable number of materials being placed in the inventory. The optimized understanding and transactions of materials would result in improved performance of the inventory. Information related to the annual value of inventory materials (in USD) in support of turnaround and shutdown activities can be used as one of the benchmarking tools for self-assessment, as these materials occupy considerable space in the inventory. By having this information, the material transactions can be planned and implemented in an improved manner. Another valuable piece of information is the percentage of materials being returned after turnaround activity. It compares the return percentage of materials with the original scope of required materials. The greater the percentage of return materials, the worse the performance of the inventory. This data would enable the inventory managers to analyze the performance of the inventory to market competitors and reveal their standing, which paves the way for self-improvement. This information is also important to analyze because the material which is ultimately being returned has no use and is holding up valuable space in the warehouses. It would help in re-evaluating the list of materials required for turnaround activity.

The skillset of the workforce employed in an inventory is important for performance. Inventory systems which develop and groom their manpower are observed to outnumber other competitors. Trainings and workshops are incorporated in the company's structure for harnessing this area of improvement. The competitor's inventory information about the type of certified training programs on materials management and inventory would allow the top-management to self-analyze the standing of their organization (in general) and inventory (in particular) in the market. This benchmarking tool can be used to evaluate and improve the workforce development structure, which significantly affects the performance of the system.

5. Conclusion

Benchmarking is a practical self-assessment tool. It provides information about the present performance of a system, relative to the market competitors, as well as paves several ways of improvement, ultimately reaching towards excellence. The present study presented a list of benchmarking tools, which can be employed in the inventory for achieving optimum performance. Several factors related to inventory management were discussed, which can be used as benchmarking yardsticks for measuring the performance of a particular inventory compared to the competitor's performance. It discussed several factors connected to the inventory optimization and materials management practices that can be used for self-appraisal. It also encompassed other benchmarking tools including materials write-off, whose information is valuable in terms of planning and implementation of efficient materials transactions. Turnaround and shutdown materials comprise significant portions of the warehouses in an inventory. The present study proposed their annual average value and material return percentages as benchmarking tools for augmented performance. The inventory workforce development through certified trainings and workshops is also recommended and considered as a benchmarking tool for self-evaluation and improvement of a system.

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Biography

Musaab Al-Rushood has a Master of Engineering from KFUPM and finishing his Ph.D. in Engineering Management at University of Sharjah, UAE. He has Over 12 years of experience with Saudi Aramco, working in Contract Procurement on several mega Gas Compression and Reservoir Storage facilities projects. He also worked in Purchasing and Inventory Control and developed several Purchase Agreements, Bid Summary Process Improvement, Materials Supply Process Mapping, and new process for executing Process Improvement projects. Mr. Al-Rushood has achieved several cost saving and cost reduction initiatives as well as several awards from both academia and industry.

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