



Role of Balanced Scorecard in Evaluating Total Productive Maintenance Performance

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Abstract

In light of the general inadequacy in the performance of the economic units operating in Iraq, and the contemporary developments in all the various sciences, Iraqi economic units have become obligated to use modern technologies applied around the world. To keep abreast of these developments, this is done by moving away from traditional methods of evaluating performance and applying approved and accepted methods of evaluating performance. This will lead to an increase in the efficiency and effectiveness of the activities of economic units. In addition, this drives to reduce of production costs. Accordingly, this study aims to clarify the application of the balanced scorecard technique and its role in evaluating the overall performance of the economic unit and the performance of total productive maintenance in particular. The study also aims to highlight the role of the balanced scorecard technique in evaluating the performance of total productive maintenance in order to develop the Iraqi industrial sector. The research selects the sulfuric acid factory in Al-Furat Company for Chemical Industries and Pesticides as a sample for the study. The most important finding is that the application of the balanced scorecard technique, based on the measures that have an impact on the overall productive maintenance, contributes to evaluating the total performance of the economic unit and evaluating total productive maintenance activities.

Paper type: Research paper.

Keywords: Balanced Scorecard, Performance Evaluation, Total Productive Maintenance.

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1. Introduction:

Total Productive Maintenance (TPM) is fundamental to production operations. It helps to improve operations efficiency, and productivity and reduce maintenance costs, which in turn improves the overall performance of the factory. However, achieving these goals requires effective management and advanced performance evaluation, and here comes the role of the balanced scorecard, as the balanced scorecard evaluates the overall performance of economic units and the performance of their activities. Among these activities is TPM. The idea of the balanced scorecard is to balance six different perspectives of performance; Finance, customers, internal operations, learning and growth, environmental, societal and risk perspectives. Performance is evaluated based on these perspectives, which help to identify areas that need improvement and to achieve the strategic objectives of the factory (Au-Yong et al, 2022).

The balanced scorecard is applied to evaluate the TPM performance by defining a set of key performance indicators. These indicators help to determine the effectiveness of maintenance and the extent to which the strategic objectives of the plant are achieved. Moreover, the balanced scorecard helps to identify areas that need improvement in total productive maintenance, such as improving productivity rates and reducing maintenance costs (Wang et al, 2022). In addition, the balanced scorecard helps to better monitor and control total productivity maintenance performance. The balanced scorecard can be used to define the main goal of total productive maintenance and ensure its achievement (Govindan et al, 2022). The balanced scorecard can be used to identify and measure key indicators of total productive maintenance performance. Financial and non-financial indicators can help evaluate the total productivity maintenance performance and point out areas that need improvement, and by monitoring key indicators, Management can identify major trends in performance and take corrective action to improve performance and achieve set goals (Maran et al, 2016; Abdurrachman et al, 2022).

Suárez-Gargallo and Zaragoza-Sáez, (2023) pointed out that the application of BSC to direct maintenance management based on the philosophy of TPM does not necessarily require organizational change or large investment, but rather requires a comprehensive vision that is promoted in the meetings held with the TPM team. Furthermore, the (BSC) represents a natural development for economic units that seek to implement the global concept of industrialization. In addition, the balanced scorecard allows the alignment of performance indicators with the proposed strategy for the planned maintenance pillar (vision, mission, and objectives) in four aspects: financial aspects, customer, internal process, learning, and growth. Chen et al, (2023) Emphasize creating value for the economic unit by measuring maintenance performance and considering maintenance strategies such as condition-based maintenance, reliability-focused maintenance, comprehensive productive maintenance, etc. In other words, the objectives are to find frameworks or models that can be used to evaluate different maintenance strategies and to determine the value of these frameworks for the economic unit.

The importance of this study comes from the fact that it discusses the performance evaluation of one of the most important activities supporting the industrial and productive operations in the Iraqi economic units. This is done by applying the balanced scorecard technique to evaluate the performance of Total production maintenance. Especially since the sulfuric acid factory, the study sample, is in constant war with maintenance because of its dealings with highly acidic materials that accelerate corrosion and resonance of parts of production machines and equipment. Through our study and follow-up of the work in the factory, we found that maintenance operations have a significant impact on the volume of production, increasing costs for production operations, and wasting a lot of time.

1.1 Study Problem

The poor general performance of the activities of the Iraqi economic units, and the failure to apply a comprehensive system to evaluate the performance of all the activities of the economic units, to improve the reality of the performance of the Iraqi economic units represent an obstacle to the progress of production in the Iraqi industrial economic units. The research problem can be represented by the following questions:

- How does the balanced scorecard contribute to improve the total productive maintenance performance in manufacturing establishments?
- What are the best-balanced scorecard measures to measure the performance of total productive maintenance in light of technological and environmental changes?
- What is the effect of using the balanced scorecard in raising the efficiency and effectiveness of the total productive maintenance process in terms of costs, quality, and speed?

1.2 Objectives of the study:

This study aims to evaluate the performance of TPM by applying perspectives of BSC, Examine the role of a balanced scorecard in evaluating total productive maintenance performance.

1.3 Study hypotheses:

The application of the balanced scorecard contributes to evaluate and identifying the defects in the performance of Total productive maintenance.

1.4 Description of the study sample:

The applied side of the research was conducted in the sulfuric acid factory. This factory is one of the factories of the Al Furat General Company for Chemical Industries and Pesticides, which is one of the companies of the Iraqi Ministry of Industry and Minerals. This study will discuss the application of the balanced scorecard technique and the extraction of performance measures that have an impact on the TPM in the sample of the study. This in turn contributes to identifying weaknesses in the performance of the Total productive maintenance.

2. Materials and Methods

2.1 The Total productive maintenance concept:

The literature shows many studies that mentioned the concept of TPM. In these studies, several concepts emerged according to point of view of researchers. TPM is a combination of total employee participation, Japanese thinking of total quality management, and “American preventive maintenance” (Maran et al, 2016). TPM is an integrated system to achieve maximum gains in production capacity and focuses on increasing the effectiveness of equipment in general (Al-Mansour, 2020). In addition to the participation of workers in improving the performance of machines and the ability to perform their jobs in a way that does not disrupt production (Alotaibi et al, 2021). It is also an approach to manage and maintain equipment and carry out maintenance work using the principle of involving all workers from senior management to middle management and executive management (Abd Ali, 2021). Total Productive Maintenance is a culture that focuses on improving efficiency by enabling people to keep all machines in good condition for the longest possible period of their useful life. TPM is also called the “Medical Science of Machines” (Kumar, 2021; Tortorella et al, 2022).

Despite the diversity of concepts presented by writers and researchers to convey the concept of Total productive maintenance, it does not go beyond being a strategy, through which integration is achieved between machines, equipment, workers, and supporting processes to maintain and improve product quality and safety of systems. It should also focus on the involvement of all workers in the economic unit in order to maximize the overall effectiveness of machinery and equipment to optimize the life-cycle cost of production equipment

2.2 Total productivity maintenance goals

TPM seeks to achieve a set of objectives that eliminate the traditional perspective of maintenance of production equipment objectives are linked with the strategic objectives of the economic unit. These objectives seek to achieve efficiency throughout the production system. They also aim to improve the efficiency and effectiveness of the manufacturing units as a whole. In other words, the goals of TPM are to achieve zero-loss performance (Prabowo et al, 2018), eliminating internal failures in productive processes, and improving the system by eliminating losses and waste (da Silva and de Souza, 2020; Zawawi and Hoque, 2022).

It provides solutions that achieve a reduction in cost maintenance by reducing the ineffective use of production resources and maintenance labour costs. In addition, it addresses the delay in identifying errors and problems (Fadel, 2020). It seeks to reduce the total costs of production, as well as the reduction of losses related to the environment (Al-Hashlamoun, 2017). Finally, it examines to create an environment that achieves a reduction in the various costs related to manufacturing, labor, and energy (Alorom, 2015).

The goals of TPM revolve around improving and developing the performance of economic units in all respects. In addition, they aim to reduce maintenance costs and reducing time costs in order to achieve the highest return through its endeavor to maintain equipment and improve its effectiveness and the involvement of maintenance workers or improving their culture by focusing on continuous improvement of all activities and operations economic unit.

2.3 Requirements for adopting Total productive maintenance

Most writers and researchers agreed that TPM includes a set of basic requirements, (Charantimath, 2011; Adesta et al, 2018; Zlatić, 2019; Luthra et al, 2020; Jana & Tiwari, 2021; Al-Refaie et al, 2022). Comprehensive productive maintenance is based on eight requirements, which are based on the organization of the workplace (5s). These requirements are:

2.3.1 Autonomous Maintenance (AM)

Levitt, (2010) determines the goal of (AM) is to find a rapprochement between the worker and the equipment. This leads to the early detection of Errors. Charantimath (2011) refers that this requirement is directed towards developing workers to be able to take care of small maintenance tasks. Therefore, this allows experienced maintenance staff to spend time on more value-adding activities and technical repairs. Autonomous Maintenance, which is Jishu Hozen's idea, is a Japanese term that means independence in judgment or mind. In addition, it is similar to what the worker does in terms of taking care of the equipment that he uses, and he constantly monitors the performance of the equipment and maintains its cleanliness and performance (Al-Mansour, 2020). Khan et al, (2020) indicate that the predominant goal of AM is to reduce system downtime and maintenance costs, which is achieved by achieving the following objectives:

- Understand the functions (components) of the system and discover the causes of malfunctions.
- Identify potential quality issues and identify their root causes.
- Timely detection of problems and self-solution.

2.3.2 Continuous Improvement

Kaizen is a Japanese word made up of two syllables: “Kai” meaning change, and “Zen” meaning well or better. Kaizen is all about striving for small improvements that are implemented continuously, which consists of people across each level within the hierarchy of economic units (Parikh and Mahamuni, 2015), According to (Mazzocato et al, 2016) the Kaizen principle relates to striving for perfection through the continuous involvement of workers in practices that enable them to incrementally propose ideas for improvement, solve problems, and maintain results over time.

Kaizen can be defined as an organized project that is implemented by a multidisciplinary team to improve a targeted area or work within a specific time frame (Bortolotti, 2018). According to Rusdiana and Soediantono (2022), the motto of Kaizen is “to preserve and motivate the human resources of the economic unit as much as possible, to encourage them to continue participating in Kaizen activities”. The application of Kaizen in the economic unit requires the cooperation of management and employees.

There are advantages of applying Kaizen in economic units as follows: (Goyal et al, 2019).

1. Increase productivity.
2. cost reduction
3. Quality improvement.
4. Optimal use of resources.
5. Better communication between management and employees.

6. Improving the morale of the workers.

2.3.3 Planned Maintenance (PM)

The purpose of the PM is to detect errors early by working to provide spare parts, maintenance tools, and the rest of the parts that help in carrying out maintenance, even electronic ones, to reduce time for searching for the information required to identify errors and repair them (Al-Mansour, 2020). Alseiri, (2021) stated that the goal of PM is to provide a guarantee that machines and equipment will operate more efficiently while achieving a reduction in traditional maintenance costs and bringing machines and equipment to an optimal level of operation in light of the compatibility of preventive and corrective maintenance added by TMP.

2.3.4 Quality of Maintenance (QM)

The goal of QM is to develop a set of plans and procedures that prevent the occurrence of internal failure due to machines and equipment to bring them to an ideal state to maintain the ideal quality of products (Venkutesh, 2007). QM is implemented in two stages. First stage is to eliminate problems related to the quality of processes and products by analyzing the internal failure of quality and working to find and determine the optimal conditions that prevent the occurrence of that failure, with a focus on continuous improvement processes. The second stage ensures the maintenance of quality by standardizing standards, methods, and methods to achieve a system free of defects and matching designs and plans related to processes and products (Singh et al, 2013). There is a fundamental link between quality and maintenance. Therefore, without machines and equipment that are properly cared for and maintained, there is no quality in product specifications. Accordingly, (Alesia, 2021) described quality management as TPM, He adds that the Japanese Institute for Factory Maintenance (JIPM), QM creates conditions that help prevent product defects and continuous control of conditions to achieve zero defects (Al-Mansour, 2020).

2.3.5 Training and Education (TE)

The behavior of workers is influenced by education and training programs, which is a very important factor for the successful implementation of total productive maintenance (Graisa, 2011; Singh and Gurtu, 2022). Training is a continuous process that is constantly reviewed and modified to consider the changing conditions and the development of previous experience and in line with new developments in the industry (Dadzie, 2019). The TPM works to improve the performance of machines, reduce breakdowns, improve working conditions and procedures, and encourage the full participation of management and workers, as it requires continuous improvement and training commitments (Dadzie, 2019). If the trainer is from the economic unit, this leads to strengthening the relationship between individuals and cooperation between them, while (Al-Refaie et al, 2022) mention that TE includes:

- Training of personnel on the principles of maintenance.
- Training of personnel to operate and maintain the equipment.
- Increase awareness of the concept of teamwork and the foundations of continuous improvement.
- Enables workers to carry out simple maintenance tasks.

2.3.6 Development Management (DM)

The issues addressed in this requirement are enhancing the workers' skills in order to reach the minimum level of problems and work on time (Ahuja and Khamba, 2008a0), In contrast, Singh et al, (2013) state that DM consists of two parts: Early equipment management and early product management, Parikh and Mahamuni (2015) state that DM aims to benefit from previous learning in developing maintenance practices for new systems by reducing problems that occurred in the current system to avoid recurrence in the new system. Zlatić, (2019) adds that DM aims to reduce the time needed to start up new equipment. Alesia, (2021) indicated that this pillar is also called maintenance prevention or early management.

2.3.7 Safety, Health, and Environment (SHE)

SHE activities aim to effectively eliminate the root causes of accidents that have occurred, prevent their recurrence, and proactively reduce the risks of potential accidents in the future by targeting near misses and potential risks (Singh et al, 2013). Jain et al, (2014) show that safety is a very important factor in economic unity, and SHE plays an active role in each of the other pillars regularly. Adesta et al, (2018) believe that SHE provides an ideal work environment free of accidents and injuries, helps eliminate abnormal conditions, and seeks to maintain the health of the workforce. Zlatić, (2019) stated that the goals of SHE are clear, which are to achieve zero accidents, zero injuries, and zero fires. Therefore, SHE is already included in all other substrates. This pillar requires each economic unit to form a separate safety department and should be able as soon as possible to prevent any injuries and to carry out safety awareness work, by organizing slogans, posters, etc. at regular intervals (Kachhadiya, 2020).

2.3.8 Total Productive Maintenance Office

The Office TPM shall be implemented after activating four other pillars AM, Kaizen, QM and PM. If these pillars are not implemented, Office TPM cannot be implemented (Ahmed et al, 2010). Singh et al, (2013) require the implementation of Office TPM to improve the productivity and efficiency of administrative functions, including analysis of processes and procedures that can be automated. Office TPM has multiple benefits represented by involving all workers with support functions to implement the TPM and focusing on improving unit performance, reducing repetitive work, reducing administrative costs, reducing inventory costs, and reducing customer complaints (Al-Mansour, 2020). Office TPM can be adopted and applied in the operational sectors, not only in the maintenance of equipment, as well as in the administrative-organizational work, and the basic idea includes eliminating losses, improving productivity, and stimulating efficiency in administrative functions. Thus, the process involves processes and procedures to minimize or eliminate losses in administrative work in administrative jobs (Alesia, 2021).

2.3.9 Organizing the Work Site

This concept was developed by (Osada) in the early 1980s and has been widely practised in many Japanese economic units. Japanese term (5S) contributes to maximizing efficiency and effectiveness. The application of (5S) can reveal hidden problems that remain unnoticed, and (5S) means five Japanese words (Naik et al, 2015). Table (1) shows these components for organizing the workplace.

Table 1: Components (5S)

Japanese term	Seiri 1	Seiton 2	Seiso 3	Seiketsu 4	Shitsuke 5
Translation into English	Organization	arrangement	purifying	profiling	discipline

(Fadel, 2020).

TPM cannot function without the implementation of its pillars formally and functionally, and one of the problems facing the implementation of TPM is the implementation of this concept by organizing the work site (5S) and ensuring its stability for the pillars of TPM (Pačaiová and Ižaríková, 2019). The eight pillars or requirements of the total productive maintenance TPM are based on a basic rule represented in the organization of the work site known as (5S), which is the cornerstone and foundation for the implementation of TPM (Fadel, 2020). As for Al-Mansour, (2020), it indicates that the organization of the work site (5S) is the continuous improvement tool Kaizen, and it is applied in production sites and administrative areas, Jana and Tiwari, (2021) indicates that the Kaizen approach focuses on (5S), which centers around waste disposal, reducing defects, increasing efficiency, and enhancing flexibility in production processes.

When applying the (S5) elements, the economic unit can achieve multiple benefits, such as a cleaner and safer workplace. And better organization at the work site, which enhances the efficiency of workers and their participation in creating an ideal work environment and thus increasing productivity. And that these elements will create an institutional environment that helps implement the pillars and pillars of comprehensive productive maintenance.

Implementing a TPM is a very complex task because its basic pillars are not compatible with all modules in general. Its implementation and level of success vary from one economic unit to another, which requires follow-up to evaluate its activities. This is done through the application of the balanced scorecard, to determine the level of performance of these activities and identify weaknesses, and then work to strengthen these points and make the best use of productive maintenance and achieve its goals.

2.4 The Concept of a Balanced Scorecard (BSC)

The Balanced scorecard BSC is one of the basic contents of management accounting (Tuan, 2020). Since its innovation by Kaplan and Norton, it is a framework for measuring and evaluating the performance of economic units and developing them. It added strategic non-financial performance measures to the traditional financial measures to give managers a clearer and more comprehensive vision of organizational performance.

BSC is a method that translates the strategy of the economic unit into clear objectives. It uses a set of financial and non-financial measures, which change with competition and major changes in foreign markets, and joint evaluation of short-term operational performance in the light of long-term strategic performance (Ojah et al, 2019). It is also considered a strategic management tool that allows control of all those procedures that represent the main variables of business management. In addition, it works to translate the organizational strategy through a coherent set of work measures that work in conjunction with other management tools (Vega Falcón and Jácome, 2020). It is also an appropriate organizational management tool for selecting a balanced set of goals and metrics that clarify the strategic vision of the economic unit in the same way that it leads it to meet the expectations of stakeholders, as well as clarifying the organizational goals with individuals once the strategy is communicated and the ability to evaluate the progress in its implementation (Vladimir et al, 2020).

BSC is also a concept of how to transform the vision and strategy into objectives and measures so that it comprehensively covers not only the areas of financial performance of the economic unit, but also the non-financial areas. It is a tool for communicating the message and strategy between the various levels of management and ordinary employees, and it is used to keep all employees informed About the processes or activities that affect the current and future success (Benková et al, 2020). It is also a strategically oriented management technique designed to evaluate and manage performance through a set of interrelated and balanced financial and non-financial measures. It is also designed to translate the vision, mission, and strategy of the economic unit into strategic objectives, objective standards and values, and clear, logical, and coherent initiatives, to assist management by providing feedback to internal operational processes and external products to develop performance and achieve strategic goals (Ali Beige, 2021).

BSC is one of the modern and important management methods for strategic cost management, which tries to find balance and integration between financial and non-financial performance measures. It is a comprehensive and integrated management technique to manage the performance of the economic units by linking their performance with the economic unit's strategic vision, mission, and strategic goals.

2.4.1 Balanced Scorecard Objective

The objectives and functions of the Balanced Scorecard (BSC) can be summarized by creating a comprehensive system for evaluating and measuring the performance of strategic economic units, and the main objective of BSC is to make the strategy the focus of attention for all employees. Therefore, it can be considered a leadership tool that helps in translating business strategy. Furthermore, BSC aims to find an organized way to link the vision of the future

economic unit with its material and human resources and its daily operations (Jarrar, 2018). It also aims to provide a framework for comparative action and translate the objectives of the strategic economic unit into a coherent and coherent set of measures (Al-Masoudi, 2018), that the total goals of BSC are as follows: (Al-Masoudi and Al-Qusayr, 2019).

1. Clarifying the vision and strategy of the economic unit.
2. Linking and communicating between financial and non-financial performance goals and measures.
3. Enhancing and strengthening the feedback to the vision and strategy of the economic unit.
4. Expressing the performance of the economic unit in its full dimensions (financing, operation, marketing, growth, environment, and society).

The goals of BSC are summed up by interpreting the vision and strategy of the economic unit to set strategic goals for each activity. In addition to linking strategic objectives with performance measures, allocating economic unit resources, and arranging implementation initiatives in a balanced manner among all activities that affect strategy implementation. This balance is achieved through BSC tools and analogues.

2.4.2 Performance Evaluating Steps of Total Productive Maintenance

The Balanced Scorecard (BSC) provides a comprehensive framework for establishing performance management systems at the level of the economic unit, and when applied to manage the performance of maintenance operations, a process that includes several steps can be followed (Campbell et al, 2016; Crespo Márquez, 2007), There is a possibility of applying the methodological reference presented by (Kaplan & Norton) Balanced scorecard (BSC) to evaluate maintenance performed according to a model called the “four-stage model” where the model adapts the conceptual base of the (BSC). The four stages consist of publishing a strategy for the economic unit, starting from the task of maintenance in the operations of the economic unit up to the performance indicators and circulating them in a descending manner. The sequence allows for capturing the strategic objectives of maintenance and translating them into performance measures.

It should take into account at each stage the Critical Success Factors (CSF) of the maintenance task, a cause-and-effect analysis between the objectives and relevant performance measures (Biasotto, 2010), and then determine the performance measures that influence the performance of the total productive maintenance. There are two main categories of maintenance performance measures. The first category includes direct or basic measures that are directly related to the collection of operational data, such as the number of maintenance procedures, type of maintenance activities, and cost. Maintenance cost per unit of product, and total maintenance costs to production costs, the second category includes indirect measures, derived from direct measures, such as reliability and availability, and some authors suggested indirect measures such as safety measures, equipment availability measures, maintenance times, overtime, approved operations, and security aspects in activities and implementation of plans and programs (Kumar et al, 2013; Dunn, 2003). Table (2) shows the performance measures that have an impact on the TPM activities, based on their strategic objectives.

Table 2: Performance measures that affect the total productive maintenance activities

Persp-ective		Scale	The equation
Financial (F)	F1	rate of return on assets %	$(\text{Net profit}/\text{total assets}) \times 100$
	F2	rate of return on investment %	$(\text{Net profit} / \text{invested capital}) \times 100$
	F3	Maintenance cost per unit of the product	Maintenance costs/number of units produced
	F4	The ratio of maintenance costs to manufacturing costs	Maintenance costs /production costs
Customer (C)	C1	sales growth %	$\text{Current year sales} - \text{previous year's sales} / \text{previous year's sales}$
	C2	Marketing Expenses Growth Rate %	$\text{Current year marketing costs} - \text{Previous year's marketing costs} / \text{Previous year's marketing costs}$
	C3	The ratio of marketing expenses to manufacturing costs	Marketing expenses/production costs
internal operations (IO)	IO1	Production capacity utilization rate	$(\text{Actual production achieved}/\text{energy available}) \times 100$
	IO2	Inventory turnover	Cost of goods sold/inventory
	IO3	The average daily performance of the worker	Number of units produced/working days
	IO4	Operational efficiency of the equipment	$(\text{Number of units produced} \times \text{optimal time to produce the unit} / \text{actual running time}) \times 100$
Growth And Creativity (GC)	GC1	Growth in training expenses	$\text{Current Training Expenses} - \text{Previous Training Expenses} / \text{Previous Training Expenses}$
	GC2	The rate of employee training expenses to total expenses	$(\text{Employee training expenses} / \text{total expenses}) \times 100$
	GC3	The rate of incentive bonuses to total expenses	$(\text{Incentive bonus}/\text{total expenses}) \times 100$
Societal Environment (SE)	SE1	The growth of social expenses	$\text{Social Expenses for the current year} - \text{Social Expenses for the previous year} / \text{Social Expenses for the previous year}$
	SE2	The ratio of social expenses to total expenses	$(\text{Social expenses}/\text{total expenses}) \times 100$
	SE3	Expenses growth of the environment department	$\text{Expenses of the Environment Department for the current year} - \text{Expenses of the Environment Department for the previous year} / \text{Expenses of the Environment Department for the previous year}$
	SE4	The ratio of environmental department expenses to total expenses	$(\text{Environment department expenses} / \text{total expenses}) \times 100$
Risks (R)	R1	Percentage of a work stoppage to total work	$(\text{Number of working days off} / \text{number of planned working days}) \times 100$
	R2	The change in the volume of demand	$\text{Current year demand} - \text{previous year's demand}$
	R3	Percentage change in product selling prices	$(\text{Current Selling Price} - \text{Previous Selling Price} / \text{Previous Selling Price}) \times 100$

(Source: Numbers of researchers based on the above)

Hence, the role of the Balanced Scorecard (BSC) in evaluating the performance of comprehensive productive maintenance TPM is represented by finding and extracting financial and non-financial measures and indicators that effect and contribute to the evaluation and identification of defects in the overall productive maintenance. Consequently, the Balanced Scorecard (BSC) is a comprehensive and integrated management technique that helps economic units evaluate the current status of their various activities and activities and set achievable goals through six perspectives (financial, customer, internal operations, learning and growth, environmental and societal, and risks). Among these activities is Total Productive Maintenance TPM. As it seeks to achieve a set of objectives, therefore, perspectives of (BSC) measures should be used to evaluate the performance of TPM.

3. Discussion of Results

3.1 Applying the balanced scorecard technique to evaluate the performance of the total productive maintenance in the factory, the study sample.

To be able to evaluate the strategic performance of the sulfuric acid factory, the Balanced Scorecard (BSC) will be employed with all its strategic perspectives. As for the sub-metrics for each perspective, they were chosen in light of the data and information available in the factory to be able to employ them in the process of measuring the efficiency and effectiveness of total productive maintenance.

Through the application of these measures, the level of strategic performance is determined for each of the perspectives of the balanced scorecard, and then this performance is compared with the standard performance of each perspective and the difference between them is determined. To work on enhancing high-performance perspectives and addressing and improving the performance of low-performance perspectives, and to achieve this purpose, importance has been identified and given to the level of performance in the way that (10) grades are given for the level at which the factory achieved the lowest performance for each measure, and (30) grades for the level of performance The highest levels of significance for the performance results ranged between these two levels. Table (3) shows the strategic performance evaluation of the sulfuric acid factory.

Table 3: Evaluation of the strategic performance of the sulfuric acid plant

Perspective	Scale	Scale application	result	level of performance			total	%
				10	20	30		
Financial (F)	F1	227997000/1341287000×100	17%	0-5%	-10%	-15%	30	
	F2	227997000/6972132000×100	3.27%	-1%	-2%	-3%	30	
	F3	82089000/6565	12,504 IQ	18,000 IQ	12,000 IQ	6,000 IQ	20	
	F4	82089000/2,770,932,000	2.96%	-3%	-2%	-1%	20	
Financial Perspective Score (120)							100	83%
Customer (C)	C1	8248-5150/5150	60%	0-20%	-40%	-60%	30	
	C2	18990000-16901100/16901100	12%	0-30%	0-20%	0-10%	20	
	C3	18,990,000/2,770,932,000	0.69%	-1%	-2%	-3%	10	
Total Customer Perspective Score (90)							60	67%
internal operations (IO)	IO1	6565/13200×100	49.73%	0-20%	-40%	-60%	20	
	IO2	2770995000/4128080	671 time	0-200	-400	-600	30	
	IO3	6565/251	19.89 tons	-10	20-	30-	20	

	IO4	$6565 \times 0.5 / 5271^1$	62.27%	0-40%	-60%	-80%	20		
Internal Operations Perspective Score (120)								90	75%
Growth and Creativity (GC)	GC1	6459000-7200000/7200000	-10.29%	0-5%	-10%	-15%	10		
	GC2	6459000/2770995000×100	0.23%	0-1%	-2%	-3%	10		
	GC3	79810000/2770995000×100	2.88%	0-1%	-2%	-3%	20		
Learning and Development Perspective Score (90)								40	44%
Societal Environment (SE)	SE1	21,096,000-23,770,000/23,770,000	-11.25%	0-1%	-2%	-3%	10		
	SE2	21,096,000/2770995000×100	0.76%	0-1%	-2%	-3%	10		
	SE3	54000000-57,000,000/57,000,000	-5.26%	0-1%	-2%	-3%	10		
	SE4	54000000/2770995000×100	1.95%	0-1%	-2%	-3%	10		
Societal environment perspective score (120)								40	33%
Risks (R)	R1	$79^2 / 365 \times 100$	-31.23%	-10%	-5%	0-1%	10		
	R2	8248-5150	3098 tons	0-2000	-4000	-6000	20		
	R3	400,000-390000/390000×100	2.56%	0-1%	-2%	-3%	20		
Risk Perspective Score (90)								50	56%
The total points of perspectives (630), the final score for performance evaluation								380	60%

(Source: Prepared by researchers using the financial statements and information of the Planning Department)

3.2 Analysis

Through the results obtained from Table (3), we can reach a number of observations as follows:

1. The percentage of the factory's performance when applying the measures of the balanced scorecard for the data of the year (2021) and all perspectives is (60%). This indicates a weakness in the factory's overall performance, which requires a decision to be taken to improve this performance.
2. The financial perspective achieved a performance rate of (83%) when applying the standards of this perspective, which is the highest percentage compared to the rest of the perspectives the factory.
3. The customer's perspective shows a percentage of (67%). This means that the factory should exploit its preference for competitors (private factories) in the field of the sulfuric acid industry. In addition, the factory should pay attention to the field of marketing by providing several services such as delivery to the beneficiaries in the factory's tanks, providing the product in large quantities, and selling on credit. This is why competitive factories cannot provide advertising, marketing, invest in these services, and as result, weakness in the performance of this perspective.

¹ Calculated (number of working days x daily working hours) = (251 days x 21 hours = 5271 hours)

² Calculated (number of days in a year - number of days in actual operation) = (365-251) = 79 days.

4. In the year (2021) from the perspective of internal operations, the factory achieved a good performance of (75%), and this is not equal to the performance in terms of the financial perspective and the customer's perspective. What is required of operations in terms of efficiency and effectiveness?
5. As for the perspective of growth and innovation in the year (2021), it achieved a performance rate of (44%), which is a weak performance rate about the rest of the perspectives, this affects the overall performance of the factory, which requires taking measures to address performance in this perspective.
6. The lowest factory percentage is the percentage of environmental and societal perspective at the
7. rate of (33%). This percentage is very weak and indicates that the factory does not has attention to the environment and the societal issues, in which the factory carries out its activity.
8. The risk perspective in the year (2021) achieved a performance rate of (56%), which is a year of performance that requires a review of the risks resulting from operations to correct operations and avoid the risks that result from them.

According to the above analysis of the factory's performance for the year (2021), it can be said that the strategic performance of the factory is witnessing a decline, disparity, and a great imbalance between the perspectives of the Balanced Scorecard (BSC). where we find the financial perspective with a performance rate of (83%), and the environmental and societal perspective with a performance rate of (33%). that it needs to reconsider some of the total production maintenance activities to achieve the best results. We can get the required improvement can be achieved in the performance of the factory, by increasing the efficiency and effectiveness of Activities that affect performance, including Total Productive Maintenance TPM activities.

4. Conclusion

The use of the TPM strategy enables the integration of machines, workers, equipment and supporting processes to maintain production quality and systems integrity in order to achieve the maximum effectiveness of machinery and equipment to achieve the optimum cost. In addition, TPM aims to comprehensively improve and develop the performance of economic units by reducing maintenance costs and reducing the time spent on them. In addition achieve the highest return, maintaining equipment and improving its effectiveness, and involve workers in maintenance operations, and the implementation of TPM depends on a set of basic pillars that must be provided; implementation success varies from one economic unit to another. The role of the balanced scorecard is to identify the performance measures that affect and are affected by the comprehensive productive maintenance that helps in evaluating the overall performance of the economic unit and the overall productive maintenance. The balanced scorecard is one of the methods of strategic cost management. It helps in balancing the performance measures of the economic units by linking performance with the strategic vision and objectives.

The BSC also evaluates the overall performance of the economic unit by achieving its strategic objectives related to its activities, including total productive maintenance TPM. Using perspectives Benchmarking (BSC), TPM performance is evaluated. The study also finds that there is a decrease, disparity and a great imbalance in the performance of the factory. And when applying the performance evaluation of the factory by applying the scales of perspectives of the balanced scorecard, the percentage of performance in the financial perspective was (83%), while the percentage of performance from the environmental and societal perspective was (33%).

Through our study we find it is necessary for the plant management to designate a management unit that is formally and comprehensively dedicated to the implementation of TPM and all its pillars and foundations, the quality team should be trained to use modern techniques to evaluate performance, especially the use of the balanced scorecard, as they should be careful to evaluate the important aspects and issues in the activities of the study sample factory. Also, it takes addressing weaknesses in overall plant performance and balancing balanced scorecard perspectives to improve overall plant performance and improve TPM performance in particular, through the use of a variety of approaches to enhance process efficiency and effectiveness.

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دور بطاقة العلامات المتوازنة في تقويم أداء الصيانة الإنتاجية الشاملة

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مستخلص البحث

في ظل القصور العام في أداء الوحدات الاقتصادية العاملة في العراق، والتطورات المعاصرة في جميع العلوم المختلفة، أصبحت الوحدات الاقتصادية العراقية ملزمة باستخدام التقنيات الحديثة المطبقة في العالم. ولمواكبة هذه التطورات، يتم ذلك من خلال الابتعاد عن الأساليب التقليدية لتقييم الأداء وتطبيق الأساليب المعتمدة والمقبولة لتقييم الأداء. سيؤدي ذلك إلى زيادة كفاءة وفعالية أنشطة الوحدات الاقتصادية. بالإضافة إلى ذلك، يؤدي هذا إلى تقليل تكاليف الإنتاج. وعليه تهدف هذه الدراسة إلى توضيح تطبيق تقنية بطاقة الأداء المتوازن ودورها في تقييم الأداء العام للوحدة الاقتصادية وأداء الصيانة الإنتاجية الكلية بشكل خاص. كما تهدف الدراسة إلى إبراز دور تقنية بطاقة الأداء المتوازن في تقييم أداء الصيانة الإنتاجية الكلية من أجل تطوير القطاع الصناعي العراقي. حدد البحث مصنع حامض الكبريتيك في شركة الفرات للصناعات الكيماوية والمبيدات كعينة للدراسة. واهم ما توصل اليه هو أن تطبيق تقنية بطاقة الأداء المتوازن، بناءً على المقاييس التي لها تأثير على الصيانة الإنتاجية الشاملة، يساهم في تقييم الأداء الكلي للوحدة الاقتصادية وتقييم إجمالي أنشطة الصيانة الإنتاجية..

نوع البحث: ورقة بحثية.

المصطلحات الرئيسية للبحث: بطاقة العلامات المتوازنة، تقويم الأداء، الصيانة الإنتاجية الشاملة.

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