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ASSESSMENT OF THE EFFECTIVENESS OF APPLYING THE 'LEAN PRODUCTION' CONCEPT IN CHEMICAL INDUSTRY ENTERPRISES

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Abstract: *This article analyzes the method of evaluating the effectiveness of the introduction of the concept of "lean production" in chemical enterprises and develops scientific proposals for improvement. Evaluation criteria are updated to take into account various internal and external factors and practice-oriented approaches are proposed.*

Keywords: *lean production, chemical industry, efficiency, chemical industry products, competitiveness, management.*

1.Introduction

In the face of intensifying global competition, rising input costs, and increasing demand for sustainable operations, chemical industry enterprises are compelled to re-examine and optimize their production practices. One prominent managerial and operational philosophy that has gained widespread attention across manufacturing sectors is the concept of "Lean Production." Originating from the Toyota Production System, lean production emphasizes the elimination of waste, continuous process improvement, and value maximization from the customer's perspective. While extensively studied in discrete manufacturing, the implementation and effectiveness of lean principles in process-oriented industries, particularly chemical enterprises, remain a relatively underexplored area of empirical inquiry.

Chemical industry operations are uniquely complex due to continuous production flows, hazardous material handling, stringent environmental regulations, and capital-intensive infrastructures. These characteristics present both opportunities and constraints for the application of lean principles. Successful implementation of lean in such environments requires strategic alignment of organizational goals, process standardization, cross-functional collaboration, and investment in workforce training and change management.

This paper aims to critically assess the effectiveness of applying the lean production concept within chemical industry enterprises. The study investigates key performance

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indicators such as productivity, resource utilization, defect rates, energy efficiency, and operational cost savings before and after lean implementation. Furthermore, it explores the organizational, technological, and cultural factors that influence the success or failure of lean initiatives in this sector.

By providing evidence-based insights, this research contributes to the academic literature on lean methodology in process industries and offers practical recommendations for managers and policymakers seeking to enhance operational efficiency and competitiveness in the chemical sector.Like developed countries in the world, Uzbekistan pays special attention to the development of the chemical industry, the introduction of resource and energy-saving technologies, and increasing the competitiveness of products. In this regard, cooperation between the public and private sectors is being strengthened and an investment climate is being created. A strategy for the development of the sector is being implemented based on modernization, new technologies, and market mechanisms. Comprehensive measures are being taken to increase the competitiveness of the national economy, in particular, the chemical industry enterprises in the world. In this process, the state is implementing a number of economic, technical, and institutional changes, the main goal of which is to modernize the chemical industry, use new technologies, and increase the competitiveness of products. Cooperation between the public and private sectors is also being strengthened, and initiatives are being implemented to attract new investments. The Development Strategy of New Uzbekistan for 2022–2026, which is aimed at creating the necessary political-legal, socio-economic and scientific-educational foundations for the reforms being implemented in our country, sets the tasks of "...developing the national economy, ensuring its growth rates at the level of modern requirements".[1]

These measures, in turn, are aimed at increasing economic efficiency and ensuring economic stability, which will help the national chemical industry to successfully compete in the global market.

2.Literature review

The issue of increasing the economic efficiency of enterprises has been studied by many foreign and domestic scientists. In particular, Shameli-Sendy, D.G. Baur, N.N. Schulze, E.V. Makarova and others paid attention to the macroeconomic aspects of financial stability. Uzbek scientists, such as N.M. Makhmudov, M.A. Ikramov, and A.U. Burkhanov, have developed theoretical and methodological approaches to the development of enterprises. However, the

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strategic development of chemical industry enterprises and its organizational and economic mechanisms have not been sufficiently covered in these studies. Therefore, a more in-depth analysis of this sector is of urgent importance.

3.Analysis and results

The concept of Lean Production—originally developed in the automotive industry—has evolved into a universal management philosophy aimed at enhancing operational efficiency by systematically eliminating non-value-adding activities (waste), reducing variability, and continuously improving processes. While its core principles were shaped in discrete manufacturing settings, lean thinking has increasingly been adapted to process industries, including the chemical sector, where it presents both challenges and opportunities.

Chemical industry enterprises are typically characterized by continuous or batch processing systems, high levels of automation, significant capital intensity, and strict compliance with health, safety, and environmental regulations. These features demand a tailored approach to lean implementation. Unlike in discrete manufacturing, where inventory and workflow are visible and tangible, the flow of materials and information in chemical production is often complex, making the identification of waste and process inefficiencies more nuanced.

Key lean tools and practices—such as 5S, Kaizen, value stream mapping, Total Productive Maintenance (TPM), and just-in-time (JIT) production—must therefore be adapted to suit the continuous nature of chemical operations. For example, while JIT may be constrained by safety stock requirements and regulatory pressures in chemical plants, TPM and standardized work procedures can yield significant gains in uptime, process reliability, and resource utilization.

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Furthermore, successful lean adoption in the chemical industry hinges on organizational readiness, including leadership commitment, employee involvement, cross-departmental integration, and a culture of continuous improvement. Digital technologies, such as real-time process monitoring, predictive maintenance systems, and advanced analytics, also play a crucial enabling role in enhancing lean performance in this sector.

The analysis shows the importance of supply chain continuity in the chemical industry. In 2023, the production of phosphate fertilizers at Ammofos-Maxam JSC decreased by 40.1% compared to the plan. This was due to disruptions in the supply of sulfuric acid and a shortage of raw materials. Import volumes increased sharply, negatively affecting competitiveness.

Navoiazot JSC is a large chemical industry enterprise in Uzbekistan, producing more than 34 types of products. In 2023, the volume of goods reached 1.9 trillion soums. Inefficient use of resources, 62% of fixed assets being obsolete, and the low share of exports are affecting the efficiency of the enterprise.

Table 1 below assesses the effectiveness of managing the concept of “Lean Production” at chemical industry enterprises in the system of Uzkimyosanoat JSC. The results of the assessment show how effectively this concept is implemented in enterprises. The rating scale is expressed in seconds, and businesses are rated on a scale of 0.00 to 2.00, with meaningful descriptions corresponding to each rating. By analyzing the table based on these, it is possible to deeply understand the success, problems and opportunities in the implementation of the "Lean Production" concept.

Table-1

The results of the assessment of the effectiveness of management of the use of the concept of "Efficient production" in the chemical industry enterprises operating in the system of the joint-stock company "Uzkimyosanoat"

Company name	**Score**	Content of the given rating
"Navoiazot" JSC	1,44	Above average efficiency
"Ferganazot" JSC	1,76	Above average efficiency
Maksam-Chirchik JSC	1,24	Low efficiency
"Ammofos-Maxam" JSC	1,81	High efficiency

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"Jizzakh plastic" JSC	1,12	Low efficiency
"Kongirod Soda Plant" LLC	0,45	Very low efficiency
JSC "Dehkhanabad potash plant".	0,38	Very low efficiency

According to the table, one of the noteworthy points is that the differences in the level of efficiency between enterprises are very large. While some enterprises have achieved high efficiency, in others the implementation of the concept is significantly low. This situation can be considered as a result of the uneven management, material and technical base, human resources, level of technology and differences in strategic approaches in the system.

First of all, the score of 1.81 given to “Ammophos-Maxam” JSC is noteworthy. This indicates that the use of the “Efficient Production” concept at this enterprise is very well organized, energy and resources are used efficiently, and production processes are optimized. At the same time, it is possible that high efficiency has been achieved in the areas of reducing costs, maximizing the use of raw materials, and reducing losses. The introduction of high technologies and a high level of automation at “Ammophos-Maxam” JSC may be an important factor in ensuring this result.

The second highest result was achieved by Fergana Azot JSC, which received a score of 1.76. This was also assessed as “Above average efficiency”. It can be assumed that the measures taken at the enterprise, such as revising technological processes, ensuring production consistency, and saving raw materials, have yielded results. In particular, the favorable location of this strategically important enterprise in the Fergana Valley in terms of climate and logistics, and the availability of a workforce may have created the basis for high results. At the same time, there is an opportunity to achieve even higher efficiency by attracting new investments and updating technological capacities. In third place is Navoi Azot JSC, which with a score of 1.44 is included in the “above average efficiency” category. This enterprise is one of the largest and most diversified enterprises in the chemical industry of Uzbekistan. The capacity is large, the number of employees is large, and the types of production are wide. Therefore, the implementation of the concept of “Lean Production” is quite complex and time-consuming.

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Nevertheless, with a score of 1.44, this enterprise also shows clear efficiency. There is no doubt that certain results have been achieved in terms of energy efficiency, waste reduction, and elimination of inconsistencies in the production process. Now we will analyze enterprises with "low efficiency". "Maxam-Chirchik" JSC falls into this category with a score of 1.24. It is possible that the concept of "Lean Production" has not been fully implemented at this enterprise or the results are not at the expected level. One of the reasons may be the obsolescence of production equipment, the lack of modern management systems, the qualification of the workforce, or financial constraints. Such situations lead to increased losses in the production process, high cost, and a decrease in product competitiveness.

A similar situation is observed at Jizzakh Plastics JSC. The score of 1.12 given to it means that the concept is also low in this case. Perhaps the enterprise has a limited range of products, has difficulties in adapting to market requirements, or has an insufficient level of automation. At the same time, issues such as training personnel to implement Lean methods, reorganizing management, and rational use of resources may remain relevant. The lowest scores in the table are those of Kungirod Soda Plant LLC (0.45 points) and Dehqonabad Potassium Plant JSC (0.38 points). The concept of "Efficient Production" has been implemented to a very low level in these two enterprises, and as a result, there is almost no efficiency. This indicates that there are serious problems from the economic, technological, organizational, and strategic points. These enterprises are likely to have a lack of investment, lack of a sufficiently competitive environment, inefficient use of resources, and weak management systems.

For example, enterprises such as the Kungirod Soda Plant produce soda and related products. The production of such products is energy intensive, and inefficient use of resources can lead to significant losses. If Lean technologies are not used in this process, it will be difficult to achieve sustainable development.

Similarly, the production of products such as potassium chloride at the Dehqanabad Potassium Plant is dependent on geological conditions, the continuity of the mining process, the processing of raw materials, and energy supply. If losses in these processes are not minimized, efficiency will remain low. Frequent downtime, disruptions in supply chains, and inefficient equipment limit the possibilities of Lean production.

Analyzing the table and coming to a general conclusion, it can be seen that the effectiveness of the "Lean Production" concept at enterprises in the "Uzkimyosanoat" system varies. While the concept has been effectively implemented and is yielding results at some

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enterprises, its implementation is slow or not effective at all at others. The following measures are important to eliminate this situation:

Education and professional development: training specialists in “Lean production” at all enterprises, retraining employees, and creating corporate knowledge exchange platforms.

Technical modernization: replacing old equipment with modern, energy-efficient devices, accelerating automation and digitalization.

Revision of production processes: conducting internal audits to identify losses in processes and reduce them.

Increasing investment activity: providing financial support to low-efficiency enterprises or attracting private investors.

Systematic monitoring and evaluation: systematically monitoring the implementation of “Lean production” and its results, and introducing an annual evaluation system.

In conclusion, the table shows that the concept of “Lean Production” is not only important in the chemical industry, but also a decisive factor for competitiveness and sustainable development. By consistently and correctly implementing this concept, it is possible to achieve significant economic and environmental gains in the industry. The introduction of new technologies within the framework of the “Lean Production” concept serves to increase production efficiency at enterprises, reduce energy costs, reduce costs and limit environmental impact. The production cycle of chemical products includes such stages as raw material preparation, chemical reaction, cooling, separation and purification, quality control, packaging and storage. The time of each stage in this process depends on the technological process, type of raw material, equipment condition and personnel qualifications, and the total working time for a batch of products can last from approximately 5.5 to 44 hours. This time can be reduced or increased depending on the specifics of production, automation of processes and other factors.

Optimization of the reconfiguration time at the enterprise taken as the object above: The introduction of the SMED method made it possible to reduce the reconfiguration time of equipment for changing polymer batches from 8 hours to 2 hours. This allows for the production of more flexible batches and reduced downtime. Also, the use of the 5S method at this enterprise helped to reduce raw material losses by 10%, as well as improve the organization of the work area, which increased work safety and efficiency.

The introduction of the Just-in-time system (to reduce inventories) made it possible to reduce raw material stocks in the warehouse by 15%, which freed up additional space and reduced storage costs.

The introduction of a statistical quality control system (SQC) has reduced the percentage of defective products from 3 percent to 1 percent, which has reduced the costs of returns and rework.

4.Conclusions

Scientific perspectives on the organizational and economic mechanisms of the development of chemical industry enterprises are based on various studies, strategies and innovative approaches. The introduction of strong organizational and economic mechanisms is important for the development of the chemical industry, as they ensure the financial stability, competitiveness and long-term prospects of the industry.

When making management decisions, it is necessary to develop strategies aimed at reducing emerging risks. Modernization of chemical industry enterprises, the introduction of updated technologies and innovative processes, ensures the achievement of high efficiency. Investments should also be aimed at organizing new high-tech production.

To increase the competitiveness of chemical industry products, it is important to introduce modern technologies and efficient production systems. Markets are also analyzed comprehensively and strategies are implemented.

In summary, the implementation of Lean Production at a chemical plant allowed for a 20 percent reduction in costs, a 15 percent increase in productivity, a 25 percent reduction in downtime, and improved product quality, ultimately leading to increased profits and increased competitiveness in the market.

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