National Higher School of Technology
Department of Industrial Engineering & Maintenance

Softwares for Modeling, Simulation and Optimization of industrial processes: a comparative study

Master's thesis in
GI Engineering

AYATE Hadjer,
BOUTRICHE Wassila Doudja,

Advisor:
REZGUI Nafissa

Co-advisors:
REZGUI Wail

Academic year:
2022-2023

Abstract: The paper presents a comparison study of four popular simulation software tools, namely Arena, FlexSim, AnyLogic, and JaamSim, in terms of several criteria such as ease of use, features and capabilities, customization, visualization, scalability, integration, performance, cost, support, platform compatibility, industry-specific features, security, collaboration, user interface, and flexibility. The comparison is based on a production line model designed and implemented in each software, and the results are evaluated based on the set of criteria. The study provides a comprehensive overview of the strengths and weaknesses of each software, helping potential users to choose the most suitable software for their specific needs.

Key-words: Arena, AnyLogic, JaamSim, comparison study, Modeling and simulation, Software evaluation

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1. Introduction

Software for industrial simulation is a crucial tool for businesses in a variety of sectors, including manufacturing, shipping, healthcare, and finance. These tools give companies the ability to simulate and test various situations and procedures, which ultimately boosts operational effectiveness and lowers costs.(García-García et al., 2020)

There are various software solutions accessible in the realm of industrial simulation, each with its own distinct features and capabilities. Arena and AnyLogic are three prominent commercial options, and Jaam Sim is a less well-known but no less effective open source program.

Arena is used to quickly set up straightforward simulation models without the need for animations, it places more of its emphasis on logic and process flows than on conceptual ideas and animations as well as a preferred tool for students or laypeople without prior simulation experience, it can immediately start replicating basic business operations, primarily using drag & drop mostly uses simple graphics. If complex animations are required, implementing them will be very challenging compared to the other tools, If you want to mimic complicated procedures (for instance, a factory with lots of complex prosseses) Arena is not the best choice for it(Dias et al., 2022)(Dias et al., 2016).The drag and drop functionality of Arena is comparable to Anylogic's Graphical User Interface (GUI), but Anylogic is Java script based, therefore its primary focus is on scripting and programming the process(Lang et al., 2021a).

For programmers and developers who are able to adjust background parameters, it is the recommended option. Compared to Arena, Anylogic's animations and graphics are superior (or more easily implemented). Anylogic, which was developed by the same business that created Anylogistix (https://www.anylogistix.com/), can replicate a whole factory's process, as shown.(Dias et al., 2016)

As a result, if your manufacturing processes are complex and involve many complex relationships, Anylogic should be chosen over Arena while for non developers or programmers, Arena is a better option; nevertheless, if a lot of simulationsare necessary, getting to know Anylogic is a useful step.

Jaam Sim is an open-source simulation software for engineering and process simulation sectors. It features a sizable library of pre-built simulation tools and models, a flexible and approachable user interface, and a constantly growing user base. Version control, robust collaboration features, and visualization capabilities are also included. Although JaamSim is a strong simulation tool for many purposes,, it does not have the same industry-specific capabilities as other software, and its limited speed can be a problem for users who must produce results under pressure of time constraints.

The main distinction between Flexsim and the rest is that Flexsim begins animating the process right away. This means that the instant you push play after developing your model, the animation begins to play, and the animations are high quality. (observing the machinery operating, the factory workers transporting objects, etc.),(Pawlewski, 2018) this also implies that the logic flow and the animation don't need to be distinct (which happens all the time in Arena and Anylogic). However, Flexsim also provides the option to concentrate solely on logic flows without viewing the animation.

Once more, it's a popular option for non-technical people who want to create models rapidly. The animation in Flexsim is superior to that in the other two programs, it can be created directly in Flexsim (called the Animation Creator) and as a result, it is a decent choice if animations are the primary concern. More clicks are necessary in Flexsim before reaching how statistics are extracted from the model(*FLEXSIM: Discrete-Event Simulation Software*. N.d.).

Arena or Flexsim are your options if you are not a developer or coder, but keep in mind that if the focus is on getting precise analytics, for instance by going directly to process flows and extracting information, Arena is still the best option. Additionally, as Flexsim is more concerned with the animations than simulation, it is not recommended to run intensive simulations.

As an example attempting to depict a complex production floor with numerous simultaneous animations. It would prove difficult and cumbersome. Anylogic is the better choice for simulations with complex dynamics.

2. Simulation methods

Industrial simulation is a technique used by organizations to model and analyze their processes and operations. It allows companies to test various scenarios and make informed

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decisions about process improvements, reducing costs, and optimizing efficiency. There are several industrial simulation techniques, approaches, and software programs available, each with its own unique capabilities(Ruane, Walsh, and Cosgrove, 2023).

In numerous sectors, simulation techniques have evolved into essential tools that allow decision-makers to assess various scenarios and obtain significant insights into complicated systems without the need for field experience. By producing a virtual model of a real-world system or process, simulation methods enable users to track and examine the behavior of the system or process under various circumstances. These techniques use statistical and mathematical models to faithfully reproduce the dynamics of the system. Users can investigate "what-if" possibilities, test theories, and improve processes by conducting simulations.

Advantages of simulation techniques: Comparing simulation methods to conventional analytical methods, the following benefits are available:

Experimentation without Risk: Simulations offer a secure setting for trying out various tactics and coming to wise judgments. As a result, there are no longer any potential dangers or expenses related to actual experimentation.

Time and Cost Savings: Simulation methods reduce the time and resources required for testing and implementing changes. They allow for quick and efficient evaluation of multiple scenarios, leading to optimized processes and reduced costs.

Insight into Complex Systems: Simulations help unravel the intricate dynamics of complex systems that are difficult to comprehend using traditional analytical methods. They allow for a detailed analysis of various factors and their interactions, leading to a deeper understanding of the system behavior.

The strategies used to simulate and analyze processes are simulation techniques. Discrete event simulation, system dynamics, and agent-based simulation are the three primary methods employed in industrial simulation.(Galvão Scheidegger et al., 2018)

2.1. Discrete event simulation :

Discrete event simulation simulates a process's events sequentially. The supply chain or a manufacturing process are two examples of processes where this strategy works well. These processes have plenty of events and interactions between those events.

• A discrete-event simulation (DES) represents a system's operation as a (discrete) series of events that happen across time. Each event takes place at a specific moment in time and represents a shift in the system's state. 2020 (Wikipedia)

• Very prevalent because the typical layperson can easily interact with it.

• DES is supported by all programs (Arena, Anylogic, and Flexsim).

In actuality, DES is supported by practically all other simulation software.

• In other words, it can be used to simulate real-world or everyday events. such as planning for hospitals, warehouses and logistics, manufacturing processes, office layouts, etc.

2.2. System dynamics

The interactions between various components of a process and the ensuing feedback loops are modeled by system dynamics simulation. The interconnections between a company's production, inventory, and sales processes are a good example of the types of operations for which this approach is most appropriate.

• System Dynamics (SD) uses stocks, flows, internal feedback loops, table functions, and time delays to explain the nonlinear behavior of complex systems across time.

• Mainly used for academic works; not widely used in the industry.

• it is mostly used for high-level purposes, such as formulating government policies and commercial strategies. In other words, SD is rarely utilized by the typical person because it is used at a very high level, such as macroeconomic policy.

• Only Anylogic, out of the programs mentionned here (Arena, Anylogic, and Flexsim), can simulate SD.

2.3. Agent based simulation :

An individual agent's behavior inside a process, such as that of a person or a vehicle, is modeled using an agent-based

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simulation. This approach works best in processes with lots of agents, such those in transportation or healthcare.

• An agent-based model (ABM) is a class of computational models used to simulate the activities and interactions of autonomous agents (individual or collective entities such as organizations or groups) in order to evaluate their effects on the system as a whole.

• In other words, ABM records the individual agents' interactions and motions rather than the event that runs across time.

• A model based on the Agent is also not often employed since it is challenging for the typical person to understand (as opposed to an Event).

• It can be used to all levels (Low to High Abstraction level).

• Only Anylogic, out of the three programs (Arena, Anylogic, and Flexsim), can perform ABM modeling(Galvão Scheidegger et al., 2018).

• Nevertheless, even Anylogic users don't utilize ABM for this reason because of how unpopular it is.

2.4. Other methods :

Industrial simulation can be approached in a variety of ways, including deterministic and probabilistic simulation. While probabilistic simulation describes a process using random variables and probability, deterministic simulation depicts a process using fixed inputs and assumptions.

3. Simulation software :

There are numerous solutions for industrial simulation software, each with special features and skills. Arena, FlexSim, AnyLogic, ProModel, SIMUL8, iGrafx Flowcharter, Vensim, Promodel, Witness, and DynaComp are a few of the most well-known industrial simulation software packages. These software packages include intuitive user interfaces and robust modeling tools, making simulation creation and execution simple. Additionally, they feature sizable and vibrant user communities that give users access to support and training materials.

A crucial tool for businesses wanting to enhance their operations and processes is industrial simulation. The particular demands and requirements of the business will determine the simulation technique, approach, and software to use. Businesses can get important insights and take wise decisions to increase efficiency and success by utilizing the proper mix of methods, strategies, and software.

4. Comparative study

4.1. Conception of the test model

We chose a procedure that is easy enough to test the fundamental abilities of the instruments. A straightforward manufacturing line (*textbook*) model was modified for this purpose.. Although simple, it includes all the features—modeling, simulation, and output analysis—to assess the particular tools. A piece is distributed constantly every 10 min. The process involves three main stages:

1. Preprocessing Stage: Here, the components are prepared together to form a finished product. The assembly line has one workstation, staffed by a worker who performs a specific task, following a distribution NORMAL(20 , 5).

2. Painting Stage: After the assembly stage, the widgets are sent to the painting booth, where a machine spray paints the pieces following the distribution TRIANGULAR(2.5,3, 3.5).

3. Packaging Stage: Once the painting is complete, the widgets are sent to the packaging area, with two parallel worstations where they are boxed and prepared for shipping, following the distribution of EXPONENTIAL(1) on the first one and EXPONENTIAL(1.5) on the second.

The production line has a conveyor system that moves the pieces from one stage to the next. The speed of the conveyor can be adjusted to increase or decrease the production rate.

The production line model can be used to simulate various scenarios, such as increasing the production rate, adding or removing workstations, changing the order of the stages, or introducing bottlenecks to test the software's ability to handle different conditions.
This model can be tested on Arena, AnyLogic, Flexsim, and JaamSim to compare their ease of use, features, visualization, scalability, integration, performance, cost, support, platform compatibility, industry-specific features, security, collaboration, user interface, and flexibility(Zharko, Voinov, and Chernorutsky, 2021).

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4.2. Criteria of comparison

The authors (Motwani et al., 1998)(Vuksic, Ceric, and Hlupic, 2007)(Dias et al., 2016) present many classifications and methods for assessing simulation software.

	Arena	AnyLogic	Flexsim	Jaamsim
Main domain	Discrete Event Simulation	Discrete Event Simulation, Agent-Based Simulation, System Dynamics	Discrete Event Simulation, Process Flow Simulation	Discrete Event Simulation
Open source	No	No	No	Yes
Software lifespan	Since 1984	Since 1998	Since 1993	Since 2010
Programming Language	Proprietary simulation language	Java and Modelica	Proprietary language, Python and C++	Java
Operating systems	Windows	Windows, Mac, and Linux	Windows, Mac, and Linux	Windows, Mac, and Linux
Reference	(*Discrete Event Simulation Software,* n.d.) (Dias et al., 2022)	(*Discrete event modeling and multimethod simulation, The AnyLogic Company,* n.d.)	(*FLEXSIM: Discrete-Event Simulation Software.* N.d.)	(*JaamSim User Manual. . Software Version: 2020-12* n.d.)(*JaamSim: Discrete-Event Simulation Software. Version 2018-09. Available online:* n.d.)(Lang et al., 2021b)

	Arena	AnyLogic	Flexsim	Jaamsim
Ease of use	Medium	Low	Low	Medium
Features and capabilities	Advanced	Advanced	Advanced	Basic
Customization	Medium	Advanced	Advanced	Medium
Cost	Medium	Medium	High	Nonexistant
Visualization	Basic	Advanced	Advanced	medium
Scalability	Medium	Advanced	Medium	Basic
Integration				
Platform compatibility	Non existant	Medium (Excel and databases)	Advanced (Excel and databases)	Advanced (input and output files)
Industry-specific features	Medium	Advanced	Medium	Low
Security	Medium	Advanced	Medium	Medium
Flexibility				
Collaboration	Low	Medium	Advanced	Advanced
Reference				

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4.3. Arena :

Let's first look more closely at Arena. The user-friendly interface and simple modeling tools of this simulation software are well-known. Organizations who need to model complicated processes, like supply chain management, project scheduling, and more frequently use it. Arena also has a sizable and active user base, so help and training materials are easily accessible.

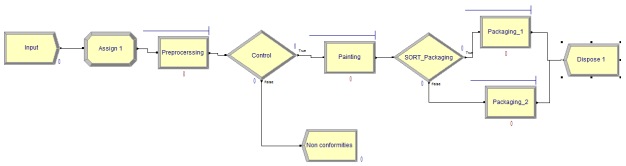


Figure 1: *Textbook model : Arena model*

One of the most significant advantages of using Arena is its user-friendly interface. The software is designed to be intuitive, and users can easily navigate through the different modules and features. The drag-and-drop functionality allows users to create simulation models quickly and efficiently, without requiring any prior programming experience.

Another feature that makes Arena stand out is the variety of pre-built templates. These templates are designed to help users get started quickly, and the pre-defined components can be customized to fit the specific needs of the simulation model. This feature saves a lot of time and effort in creating simulations from scratch, allowing users to focus on optimizing their processes and systems.

Additionally, Arena provides a range of advanced features that allow users to create highly complex models. The software's ability to handle discrete event simulation and stochastic processes makes it a valuable tool for predicting and optimizing the performance of complex systems. This feature set enables users to create highly detailed simulation models that can provide a competitive edge for businesses that use the software.

Another advantage of using Arena is the extensive documentation and support provided by the developers. The software comes with detailed tutorials and user manuals that make it easy for users to learn the software and its advanced features. Additionally, the customer support team is highly responsive and knowledgeable, making it easy to get help when needed.

One of the most significant downsides of Arena is its learning curve. While the software is designed to be intuitive, it can be overwhelming for beginners who have no prior experience in simulation modeling. This can make the software less accessible to those who need it the most. Users may have to invest significant time and effort to learn how to use the software effectively.

Another issue with Arena is its pricing. The software can be costly, making it difficult for small and medium-sized businesses to afford. This can limit the accessibility of the software to those who need it most. Additionally, the licensing fees can make it challenging to maintain the software in the long term, especially for companies with limited resources.

Another limitation of Arena is its limited support for continuous simulation. The software is primarily focused on discrete event simulation, and while it does provide some support for continuous simulation, the support is not as robust as it is for discrete event simulation. This limitation can be a significant drawback for users who need to model complex systems that require both types of simulation, since it mainly focuses on the system and its logic as a whole rather than flow or components.

Finally, while Arena's user interface is generally intuitive, the software can be complex and challenging to use in certain circumstances. For example, creating custom reports can be cumbersome and time-consuming, and the software's output reports can be difficult to read and interpret. This can be a significant limitation for users who need to communicate simulation results to stakeholders effectively(*Discrete Event Simulation Software,* n.d.) (Dias et al., 2022).

4.4. AnyLogic :

Let's go on to AnyLogic. Using a variety of simulation techniques, such as discrete event simulation, system dynamics, and agent-based simulation, this software's multi-method simulation platform enables users to model complicated processes. Additionally, AnyLogic provides a sizable library of pre-built models, which enables companies to easily start modeling their operations right away. The software is also a popular choice in sectors like transportation, logistics, and healthcare due to its advanced capabilities, like its capacity to replicate the flow of people and vehicles.

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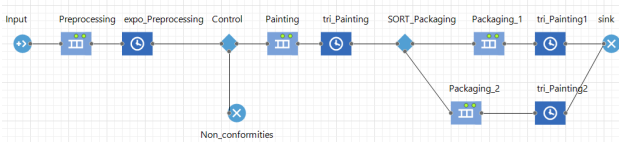


Figure 2: *Textbook model : AnyLogic model*

AnyLogic offers an intuitive graphical user interface that is easy to navigate. The interface is well-organized and offers a range of modeling tools that make it easy to create and manage simulation models, including discrete event simulation, agent-based modeling, and system dynamics. This makes it a versatile software that can handle complex simulation models.

The software has a user-friendly interface that allows for easy drag-and-drop model building same as Arena.

AnyLogic offers a range of customizable options that allow users to tailor the software to their specific needs. Users can create custom components and design simulation models to meet their unique requirements, modify existing models or create new ones from scratch. It has remarquable object-oriented modeling capability, since it is developped on JAVA.

Contrary to most other tools mentionned here, Anylogic is designed to integrate with other software, including Excel and databases, allowing users to import and export data from other software to the simulation model with relative ease.

AnyLogic still can be a challenging to learn, its wide range of tools can make it overwhelming for users who are not familiar with modeling.

While it offers a graphical user interface, the GUI features are somehow limited, especially in comparison to the other simulation software. Some users may prefer a more intuitive and customizable one.

It also does not offer pre-built template models that can be used as a starting point for new simulations. This can be a disadvantage for those who are new to simulation modeling and need a baseline model to get started.

AnyLogic offers a range of modeling tools and features, but users may find that some aspects of the software are not as customizable as they would like. This can be frustrating when trying to create a specific model.

AnyLogic is a proprietary software, and its licensing costs can be expensive. For some organizations, the cost may be prohibitive, especially for small or medium-sized companies.

The graphic rendering can be slow when handling large data sets. This can be frustrating for users who are trying to visualize the results of their simulation models.

While AnyLogic offers customer support, some users have noted that there are not as many online resources available, such as forums or community pages, compared to other simulation software. This can make it difficult for users to find answers to questions or connect with other users(*Discrete event modeling and multimethod simulation, The AnyLogic Company,* n.d.)(Lang et al., 2021a).

4.5. Jaamsim

Let's look at Jaam Sim last. The engineering and process simulation industries are the target markets for this open-source simulation software. It has a wide library of pre-built models and simulation tools, a flexible and user-friendly user interface that makes it simple to build and simulate complex processes. Jaam Sim also includes a rapidly expanding user community, which enables users to get support and training materials from other users.

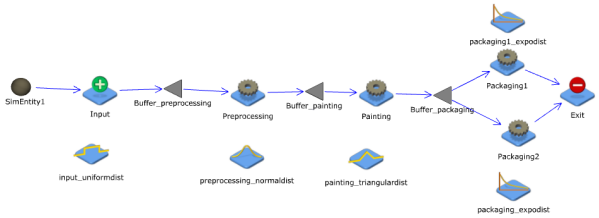


Figure 3: *Textbook model : Jaamsim model*

JaamSim's user interface is not only easy to use but also highly customizable. Users can modify the look and feel of the interface to suit their preferences, including changing the colors, fonts, and layout of the simulation window. This flexibility is particularly useful for users who want to create simulations that match their organization's branding or visual style.

Another key feature of JaamSim is its visualization capabilities. The software allows users to view their simulation models in real-time 3D, which helps to better understand how the system is working. The ability to add animations, graphics, and charts also makes it easier to communicate complex data to stakeholders.

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JaamSim also has strong collaboration features, allowing multiple users to work on the same simulation project simultaneously. The software supports version control, allowing users to easily track changes and collaborate with team members.

Compared to other simulation software options like AnyLogic or FlexSim, JaamSim may have more limited features and capabilities. This can be a challenge for users who are looking for a more robust set of tools for simulating complex systems.

Lack of Industry-Specific Features: While JaamSim is a powerful tool for general-purpose simulation, it may not have the same industry-specific features as other software options. For example, users working in manufacturing or healthcare may find that JaamSim does not have the same level of features as software that is designed specifically for those industries.

Limited Performance: Running simulations can be slow, particularly when working with large or complex models. This can be a challenge for users who need to generate results quickly or who are working with tight deadlines(Ruane, Walsh, and Cosgrove, 2023)(*JaamSim: Discrete-Event Simulation Software. Version 2018-09. Available online:* n.d.)(WinNT2).

4.6. Flexsim

FlexSim is the simulation program that Arena users use the most frequently. Numerous simulation options are available with FlexSim, such as discrete event simulation, system dynamics, and agent-based simulation. It is simple to develop and perform simulations thanks to its intuitive user interface and strong modeling tools. Additionally, FlexSim has a sizable and vibrant user base that gives users access to training and support materials. FlexSim is a popular option for businesses across a variety of industries, including manufacturing, logistics, and healthcare, because to its broad range of industrial applications.

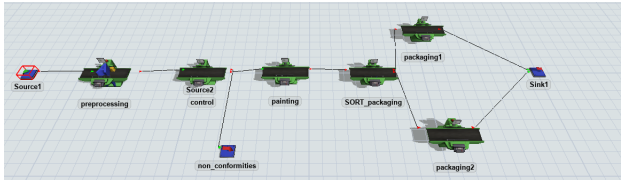


Figure 4: *Textbook model : Flexsim model*

FlexSim provides comprehensive support for a wide range of modeling techniques, this means that it is a versatile solution for many different types of business and engineering problems. It has a user-friendly interface that makes it easy for users to get started. The software allows for easy drag-and-drop, as well as real-time visualization of simulation models, allowing users to view the impact of changes on the model as they are made. This feature helps users to analyze and optimize the model in real-time.

FlexSim is scalable and can handle large and complex simulations. This feature is especially useful for large companies and organizations.

Similar to Anylogic FlexSim is designed to integrate with other software, including Excel and databases.

Some users may find it less visually appealing and less intuitive compared to other simulation software. This may make it more difficult to create models quickly or collaborate with others who may be less familiar with the software.

Even though it runs on Linux and Mac, it is primarily designed to run on Windows-based systems, which may limit its compatibility with the other operating systems. This may be a disadvantage for users who prefer to work on other platforms or who work in a multi-OS environment. On top of that, FlexSim is a high-end simulation software, and it comes with a correspondingly high price tag.

5. Conclusion

Since each of these industrial simulation software solutions has advantages and disadvantages of its own, the decision of which software to employ will primarily depend on the particular demands and specifications of the company. Businesses that need to mimic complicated processes should use Arena, whereas those that need to model a variety of simulation techniques might consider AnyLogic. Although Jaam Sim is a more recent alternative, it is an excellent one for companies who require an open-source solution and a growing user base. The sort of operations a firm needs to emulate, along with its budget and technological constraints, will ultimately determine the optimal software option.

All these softwares have successfully complied with the fundamental simulation requirements in the majority of the models' simulations. Yet, there are differences in usefulness

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as compared to discrete-event simulation and debugging. For example Anylogic, which is object-oriented and can support Java scripts, and Arena, which is process-oriented and doesn't require any coding—have different very different simulation building methods(*FLEXSIM: Discrete-Event Simulation Software.* N.d.)(Galvão Scheidegger et al., 2018)(Pawlewski, 2018).

The choice of simulation software ultimately depends on the specific needs of the user, and this study provides a valuable guide for selecting the most appropriate software.

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Notification of Acceptance

Dear Colleague M. Boutriche Wassila Doudja

We are pleased to inform you that your paper titled *"Softwares for Modeling, Simulation and Optimization of industrial processes"* has been **accepted** as **Virtual presentation** to be presented at the First National Conference On Industrial Engineering And Sustainable Development (ICESD'23) which will take place on Mai 16-17, 2023 in Relizane, Algeria.

The ID of your communication: CIESD'23_CDO001

Thank you in advance for your contribution toward the success of ICESD 23. We look forward to welcoming you in CIESD, Relizane, Algeria.

President of the scientific committee

Pr. YSSAAD Benyssaad

First National Conference On Industrial Engineering And Sustainable Development **CIESD'23**
Mai 16-17, 2023 in University of Relizane, Algeria.



Notification of Acceptance

Dear Colleague M. Hadjer Ayate

We are pleased to inform you that your paper titled *"Perfomance improvement using the six sigma methodology : a case study in the pharmaceutical industry"* has been **accepted** as **Virtual presentation** to be presented at the First National Conference On Industrial Engineering And Sustainable Development (ICESD'23) which will take place on Mai 16-17, 2023 in Relizane, Algeria.

The ID of your communication: CIESD'23_CDO007

Thank you in advance for your contribution toward the success of ICESD 23. We look forward to welcoming you in CIESD, Relizane, Algeria.

President of the scientific committee

Pr. YSSAAD Benyssaad

First National Conference On Industrial Engineering And Sustainable Development **CIESD'23**
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Proceedings of M. I. E. G. I. M. - 2022/2023