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SOLVING THE LOGISTICS PROBLEMS OF PRODUCTION INVESTMENTS WITH A SIMULATION TEST METHOD

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Abstract: As a result of the increasingly diversified customer needs, investments to transform the production system are gaining prominence. Due to the complexity of the transformation, in many cases there are logistical problems that hinder the current and/or future satisfaction of customer needs due to inadequate planning. The paper also explores the types of possible logistics problems that may occur after the implementation of the investments, as well as the steps of applying a simulation test method to address them.
Keywords: keywords production investment, logistics, simulation

1. INTRODUCTION

Nowadays, logistics planning remains a key step, using both Industry 4.0 technologies [1] and the tools of mechanical engineering technology [2] for any change in a manufacturing plant. Logistics planning begins with the definition of the logistics requirements for the investment, followed by the selection and placement of technological equipment, material handling equipment and lastly the storage system. At the same time, the design of the information flow system must take place.

An investment requires a different approach in each case, as they are strongly influenced by, for example: the diversity of the products, the size of the production and location, the internal design, the connection points of the resources and energy as well as the ever-present financial framework. In addition, the devices and equipment required by law and labor protection, like the safety distances, the fire barriers separating the manufacturing and storage units and the passageways for both people and devices must not be neglected.

The article describes the typical problems that arise due to poorly implemented investments due to design errors, their possible effects on the operation of the company, and the steps of the simulation test method that can be used to solve the problem.

The logistics simulation do not always mean a large and comprehensive set of methods that represent the whole system, sometimes it is enough to examine only one part of it, which can be done with simple mathematical and statistical tools, or in most cases a spreadsheet is very helpful [3]. However, for more complex tasks, e.g.: application of a simulation framework capable of examining a warehouse and its external/internal logistics [4], [5], [6]. In external logistics, supply chains can be examined primarily with the help of route planning and modeling software [7], [8]. Complete supply chains or whole city logistics can be also investigated with the help of transport analysis software [9], [10].

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There are a large number of internal logistics simulation software on the market [11] with different features depending on their graphical interface, ease of application, built-in or optional model and object storage, that can be fast or have high computational performance. One of the most important is the cost at which it can be obtained. A very good example of simulation software is ExtendSim, which although not specifically designed for logistical problems, can also be applied to it [12]. The simulation approach may also be used to determine the relationship between cross-border customs and trade risk [13]. The simulation-based decision support system is preferred in logistics management [14]. The way to eliminate bottlenecks in the logistics process can be determined with the help of the modules in the Tecnomatix Plant Simulation framework with a short lead time [15].

Based on the literature reviewed, it can be concluded that there is no uniform method to deal with these problems and simulation is rarely used

2. DESCRIPTION OF LOGISTICAL PROBLEMS IN PRODUCTION INVESTMENTS

Ideally, after the implementation of an investment for conversion, production will start properly and no defects will arise later on. However, in reality, in many cases, errors arising from preventive faulty logistics planning occur as production surges or expands. Investment risks can be reduced by a variety of solutions, such as modular technologies [16], but there are nevertheless a number of logistical problems that are presented in this chapter.

2.1. Incorrect selection of new technological equipment(s)

During the production needs of a product, the size, complexity, and equipment requirements of its series are assigned, and the individual technological equipment is selected accordingly. For example, an automotive component that consists of one or more pieces. In the case of the production of a single piece of part, some kind of material processing or deformation typically occurs. During production planning, a specific technological equipment is selected, which performs the given technological process. However, during the start of production it may turn out that although the given technological equipment produces the product, its production volume is not in line with other technological equipment and working environment. This brings with it a difference in the cycle time of each equipment, even with several differences in order of magnitude. This means that the utilization rate of the oversized technological equipment is significantly lower than that of other equipment. Thus, in this case, it would have been sufficient to purchase a machine with a lower production volume, which would have resulted in a reduction in cost and space utilization. To avoid incorrect machine selection, a simulation design is recommended, where the difference between each volume can be found before the actual investment.

2.2. Incorrect selection of new handling equipment(s)

When determining the production demand, not only the selection of technological equipment is carried out, but also the design of the logistics processes serving it, one of the elements of which is the choice of material handling equipment. A material handling device can be very diverse, such as forklifts, cranes, roller tracks, conveyor belts, etc. In the case of handling equipment, it shall first be determined whether it is continuous or intermittent and whether it carries pieces or bulk goods, and then the specific handling equipment may be selected on the basis of the additional conditions. However, after an investment, it is also possible that the equipment is not suitable for the production or transport volume. For example, in the case of a forklift or crane transport, the transport or loading is too slow or, on the contrary, the occupancy of the equipment is too low. In this case, it would have been advisable to choose a larger or smaller forklift or crane, respectively. Here, simulation design is also able to eliminate the too much oscillations.

2.3. Improper placement of technological equipment(s)

During production planning, it is necessary to choose not only the type of individual equipment, but also its arrangement in order to ensure the efficiency of the logistics process. Nowadays, many proposed layouts can be used to reduce material handling work, cycle time, and lead times. If the technological equipment is not properly installed, it may cause more problems. One of these is the increase in handling work, for example, a forklift or roller track has to go a long way. In the former case, energy consumption and lead times increase, and in the second case also the purchase cost increases due to the increase in length. Another problem may be the crossing of material flow paths, which at best causes only a slowdown, at worst it already leads to an accident. These can be corrected afterwards at a very cost and time and cause a complete shutdown of production, so it is advisable to plan and examine these layouts in advance by simulation.

2.4. Mis-placement of in-action container(s), warehouse(s)

A logistical process contains of not only loading and transport, but also storage, for which smaller containers are used, warehouses on a larger scale are used. When planning a production logistics process, the cycle time of each technological process should be taken into account and, if different, temporary containers should be installed. Additional storage is required when handling the incoming and outgoing product. If a temporary storage facility is not of sufficient size, i.e., smaller, or larger than would be necessary, the technological equipment may lead to a downtime or unnecessarily large storage, respectively. The same is true for warehouses, but the improper choice of warehouses may hinder or even halt the entire production process, resulting in a significant loss for the production company. If these need to be amended afterwards, it is again a cost-consuming and time-consuming process and can lead to a halt in production. With an efficient simulation design, these containers and warehouses can also be efficiently designed.

2.5. Incorrect choice of operational strategy

In today's ever-changing world, production needs to be constantly redesigned. Production planning shall aim at ensuring that production always runs properly, regardless of the number, size and type of product to be manufactured. By choosing a correct operational strategy, these swings can be handled well and thus ensure continuous production. Production planning should also take into account maintenance periods and adjust production volumes to this. An incorrect choice of strategy would generate continuous interruption, thereby reducing the utilization of equipment. This ultimately results in a lower profit for the company. Simulation design shall take into account the maximum expected number of products and the consideration of extreme values, for instance minimum and maximum size.

3. DESCRIPTION OF THE MODEL OF SIMULATION METHOD

As already mentioned, simulation studies have long been present in almost all fields of science [17], and only our computational capacity, the quality of input data, and the ability to solve problems with human/artificial intelligence can limit the scope of studies in that field. The main principles and design steps of the various simulation tasks have already been described generally in the literature, but each field has its own specialties, which if we don't take these into account we can easily run into problems. This is no different in the field of Logistics.

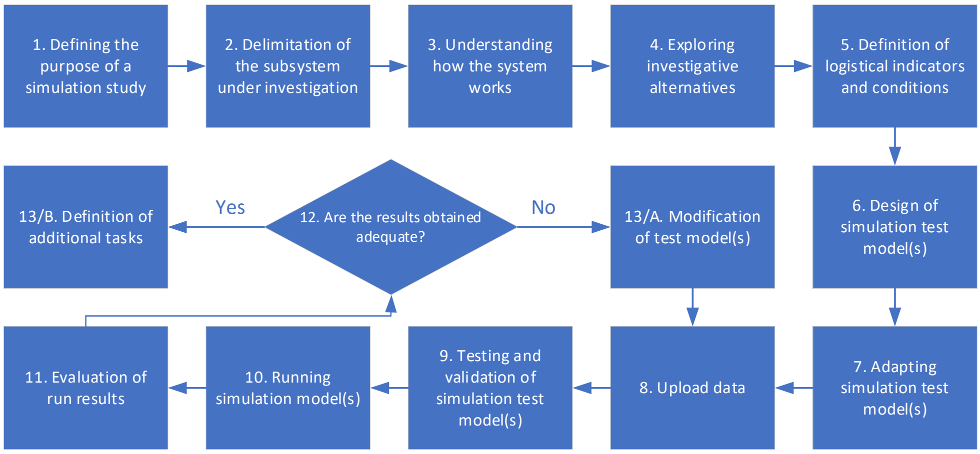

Figure 1. The general simulation model of logistics system

The model described in Figure 1. illustrates the simulation testing and design steps of logistics systems to address issues, that arise after the implementation of logistics investments. The model was developed based on projects conducted at several companies, where we provided surveys, inspections and proposed modifications of various sizes and depths, primarily for their entire internal logistics system. The steps of the simulation test are described below.

1. Defining the purpose of a simulation study

The initial step is one of the most important steps, as it determines the type, difficulty and, most importantly, the expected outcome of the study. Even before the tests and data survey, it is necessary to decide what, how long, and in what detail we will examine the system. Subsequent changes can make it very difficult to move forward, as the entire test model may need to be rebuilt.

2. Delimitation of the subsystem under investigation

Unfortunately, it is almost impossible to test a complete logistics supply chain system, and above a certain level the uncertainty of the data is so great that the results obtained would not cover reality. For this reason, it is necessary to delimit a subsystem of appropriate size and reliability. Any process that falls outside this subsystem will only appear as a source and drain element for materials and information, which will manufacture or supply the material “from nothing” and then disappear at the border of the subsystem.

3. Understanding how the system works

Once the goals and objectives have been defined, a comprehensive picture of how the system works should be obtained. We usually solve this with on-site visits, which are guided by the current company’s specialist. It also includes learning about the corporate culture, reviewing floor plans, and getting to know the basics of software, databases and internal communication devices and methods.

4. Exploring investigative alternatives

Once the task has been clarified and the investigators are fully aware of the situation, a decision must be made as to the means and depth of the investigation. In addition, at this point, one or more future states are already beginning to emerge, which may be presented by the investigators or the company’s experts. These versions will be refined and tested later.

5. Definition of logistics indicators and conditions

In order to perform the examination, it is absolutely necessary to give or create some numerical result that the simulation-capable will tool calculates, and in addition, indicators and limits are needed with which we will be able to compare the different variants. These are very important to determine, the depth and accuracy of the data greatly determine the output compliance, and they can significantly reduce data collection (eliminate unnecessary data.

6. Design of simulation test model(s)

In this step, the simulation phase is designed and broken down into tasks, taking into account the adaptive capacity and tools of the specific program. It can be said that the following solutions are preferred for logistics simulation:

a) Siemens PLM Software: Plant Simulation, which allows real-time material movements to be tracked and applied when a complex test is performed, such as: installation layout, acquisition of a new device, or testing across several parts of a building / unit [18].
b) MS: Excel, which can be used to perform simpler, mainly simple mathematical simulations, such as: inventory testing or production scheduling.

7. Adapting simulation test model(s)

Starting from this phase, a basic has been created from the measured and obtained data. This will be the simulation basic model for future uses. We usually create a current state model that contains: the layout, routes, and schedules.

8. Upload data

The already created model needs to be completed with uploaded measured or received data and then the behavior of the machines, sensors and tracks must be set.

9. Testing and validation of simulation test model(s)

If a current model has been developed, the results obtained should be compared with reality, if possible. This greatly reduces the chance, that some error will remain in the model later on, which will affect the outputs of future plans. If there is no model of the current state (e.g. a completely new factory), validation is still required, which can be provided by comparison with pre-calculations, component testing and review by several specialists.

10. Running simulation model(s)

In this phase, the validated simulation model(s) must be run several times in the simulation platform.

11. Evaluation of run results

Taking into account the objectives, indicators and conditions set out in points 1. and 5., we will determine whether the model will be able to meet the expectations in reality or not. To do this, most simulation software has a built-in toolbar that consists primarily of statistical and efficiency units.

12. Are the results obtained adequate?

If all the conditions are met in one or more of the models defined in points 1. and 5., then the selected model may be introduced in reality, and step 13/B. may be taken, in which further action can be defined.

13/A. Modification of test model(s)

If the goals, indicators or limits are not met for a model, it should be discarded in the worst case, but in most cases better results can be achieved by making changes in the model or changing the basic data. Striving for the best possible solution in simulation studies is an iteration process, which is also included in the between steps 8 to 12.

13/B. Definition of additional tasks

In this step, the implementation is based on the selected model variant.

4. Summary

In the paper, a topic is presented that provides an answer to one of the most important logistics problems of today, namely the treatment of logistics problems after the implemented investments. The most important logistics problems in practice and their possible effects on the operation of the company were presented. In addition, a simulation testing process has been developed that can be used to manage the entire re-engineering process to an appropriate standard, starting with the definition of objectives. In the following, we will focus on the practical application of the developed method and its extension to different areas.

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