

OPTIMISATION OF INSPECTION STRATEGY IN PICKING AND PACKAGING BY USING SIMULATION

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Abstract:

Picking and packaging is the last step between the company and their customers. The returns succeeding the order cost up to the tenfold. In order to recognize the occurrence of non-conformities on time before delivery to the customers and to decrease the failure removal costs within the returns processing, quality inspections have to be integrated in the routing of picking and packaging. This leads to complex interactions between individual picking and inspection processes. Therefore, quality, costs and cycle time are difficult to estimate. The problem can be solved by using simulation, which has become a powerful tool. In fact good simulation systems are already available for the tasks of calculating manufacturing costs, analyzing cycle times or estimating quality. Unfortunately there are no such similar systems for the picking, packaging or return processes.

The choice of a suitable inspection strategy concerning quality, costs and cycle time is supported by the designing of a comprehensive reference model for the picking and packaging. This model enables to estimate the optimal inspection extent and point of time of inspection in picking and packaging during the planning. With this purpose a differentiation between handling and inspection processes within the picking must be taken in consideration.

By a determination of costs, cycle time and a probability of failure occurrence for every process, an evaluation of non-conformance costs will be possible. The simulation of different picking scenarios and their evaluation permit a selection of an optimal inspection strategy.

Keywords: inspection strategy, picking, packaging, simulation

1. INTRODUCTION

Taking and collecting a specified quantity from a provided amount of different articles to satisfy intern or extern customers' orders are the main aspects of order picking. With it, manual picking is especially common in small and medium-sized companies due to high flexibility at adequate performance and low inventory costs. The aspect of flexibility of manual order picking is often just neglected in practice and its economical potential is not fully exploited. Rearrangements of the order picking process, if ever, only occur in huge time intervals, because potential improvements cannot be identified. Within making this process more flexible, the paper provides an approach to adapt manual picking to unstable order situations by modifying inspection activities. On the basis of simulations

of the picking process, a selection algorithm is developed which enables the user to establish appropriate inspections in the process chain and to make short term decisions in favour or against the implementation of specific inspection activities depending on the current situation.

Order picking process is addicted to short term variations. Even within a short period as one day, considerable differences according to customers dispatching can be found. These differences being mainly significant in the Business-to-Customer sector reflect the ordering behaviour of the customers. Consequently, the number of incoming orders in the evening is usually significantly higher than in the middle of the day. Considering these aspects, it is obvious that a medium term invariable order picking process, as it is common in the industry, does not take advantage of the great potential of manual order picking flexibility. Actually, a short term adaptation of the process depending on the current situation is desirable. Due to the limited planning horizon, neither adaptations regarding personnel restructuring, nor a change of the picking system can be realized. Short term modifications can be made just by concerning the organizational structure which defines the execution design of the picking process. For the execution of the picking process, two important factors are largely responsible: the picking strategy and the inspection strategy.

The picking strategy can be regarded as a determination of the temporal-spatial picking processing [tenH08]. These strategies offer multiple options to flexibly adapt a picking system to the current prevailing situation. Especially, picking routes can be modified at short term, virtual zones can be adopted and multi-order-picking can be implemented.

Inspection strategies refer to kind and scope of inspections that are integrated into the picking process. They serve the goal to assure a high picking quality. A specific inspection strategy is defined by all single inspections integrated into the picking process. These single inspection activities can be activated or deactivated independently of each other with a low organizational effort, provided that the technical conditions for their realization are satisfied.

Consequently, with picking and inspection strategies, there are two different ways to appropriately modify the picking process according to the current situation. Within the scope of the project Flexkom [1], which was carried out by Technical University of Dortmund in cooperation with the Dortmund Initiative zur rechnerintegrierten Fertigung (RIF) e. V., it was examined how to use these strategies for implementing a flexible and efficient picking process. The reason of the research being based on simulations of the

picking process was to develop a selection algorithm for the application of picking and inspection strategies in a manual picking process which are appropriate to the prevailing situation. This selection algorithm makes it possible to react flexibly to an unstable system load and to apply the ideal combination of picking and inspection strategies at any time. Therefore, the whole efficiency of the picking process is improved.

2. BASICS OF ORDER PICKING AND PICKING STRATEGIES

In this section, a brief introduction will be given to provide the basics of manual picking processes. The general process chain will be explained and two specific picking strategies which are considered in detail in this paper will be discussed.

For illustrating the picking process, a simple process chain is depicted in Figure 1:

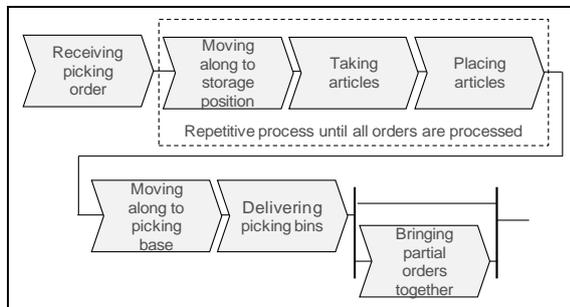


Fig. 1: Process Chain

The picking base is both the starting as well as the final point of the picking process. After receiving the picking order, the operator prepares so called picking bins depending on the number of customer orders that are merged into the picking order. If multiple orders are handled simultaneously, several order bins have to be carried along (Multi-Order-Picking). After this, the actual picking process begins. The operator moves on to the first position of the picking order. When reaching the providing unit, he takes the requested quantity of articles and deposits them into the picking bin. If more than one picking bin is carried along simultaneously, the operator must assign the collected articles to the appropriate picking bin respectively to the appropriate customer order. Afterwards, he moves on to the next order item. These process steps are repeated until all items of the picking order are processed. Once this is accomplished, the operator returns back to picking base and delivers the picking bins. If only a part of a customer order has been processed by the operator (Virtual Zones), the partial order has to be brought together with the other parts.

3. PICKING QUALITY

In addition to performance, a holistic appraisal of picking strategies contains the consideration of quality aspects. This section will discuss those quality aspects and gives a brief introduction to an approach to measure the picking quality referring to a special classification of

picking errors. Based on these errors it will be explained afterwards how the two considered picking strategies influence the quality of the picking process.

The Error classification, which applies within this paper, is based on Lolling [3] who differentiates between four different types of picking errors:

- Type errors result from picking wrong articles. They are caused when another article than the intended one is picked, when the intended article is missing or when additional non-intended articles are picked.
- Quantity errors occur when the correct types of articles are picked in wrong amount.
- Missing errors are caused by the omission of one or more items and when a wrong or no other article is picked instead of the intended one.
- Condition errors have to be distinguished from the other types of errors, because they do not assess the presence or absence of articles but their condition. They occur when articles are damaged or any services are missing (e.g. packaging, labelling, etc.).

Those four different types of errors are all illustrated in Figure 3. The order as it is supposed to be picked by the operator is shown at top of the figure. Below there are the results of different types of picking errors.

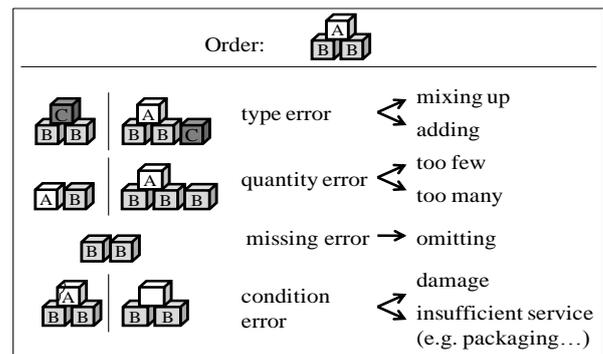


Fig. 2: Picking Errors

Regarding the presented error classification, it has to be examined, how picking strategies affect the occurrence of those types of errors. Thus, the modifications in the process that are accompanied by the implementation of Multi-Order-Picking and Virtual Zones have to be considered. What are the additional handling activities that occur and what kind of errors are caused by those handling activities?

If a Multi-Order-Picking is applied, the storage situation is mainly affected, as the complexity of this handling activity rises with the increasing number of orders that have to be processed simultaneously. The higher the amount of picking bins carried along, the more possibilities exist to make mistakes in assigning articles. If an article is assigned wrong, a so called storage error is caused.

To apply Virtual Zones in a picking system is insofar of essential importance for the achieved quality, as the picking process is extended by additional handling activities for combining partial orders. If this consolidation is done incorrectly, this leads to so called combining errors.

Figure 3 shows an illustration of storage and combining errors. Once more the correct orders are shown at the top of the figure. Below there are typical examples of combining

and storage errors with regard to results of the picking process.

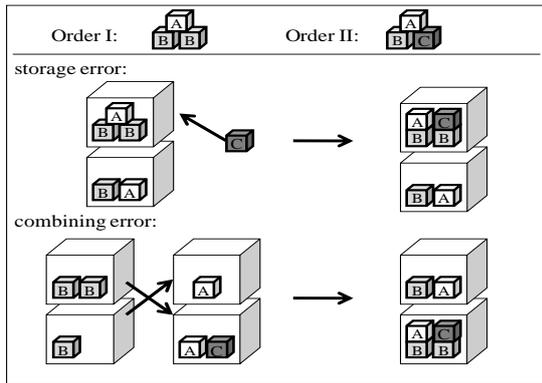


Fig. 3: Errors caused by Multi-Order-Picking and Virtual Zones

Both storage and combining errors differ from the four error types that were mentioned above, as they have a different reference object. While type, quantity, missing and condition errors assess the order itself, storage and combining errors consider the corresponding process step. Therefore, the different types of errors have a common intersection and cannot be separated completely from each other. A storage error usually leads to missing or quantity errors in the order which was originally scheduled for the article. At the same time, the article is allocated to another wrong order and causes an error in this order. The situation is similar if combining errors occur: These errors also cause various types of errors in several orders. Consequently, storage and combining errors can be considered within the four original types of errors which are defined by Lolling.

4. TARGET FIGURES FOR A HOLISTIC PICKING PROCESS ESTIMATION

The remarks which were made in the previous chapter are discussing the effects of picking strategies qualitatively. For being able to give the intended holistic estimation of the benefit of picking strategies, it has to be assessed how strong these effects are. Hence, specific target figures and a method to make a prediction about the quantitative impact of picking strategies on these target figures are required.

With the intention of estimating quality and performance, two target figures have to be taken into account. Different measuring units are needed to characterize them:

- Performance of a picking process can be measured by the time which is necessary to process an article. Correspondingly, it consists of the travel time and the handling time that corresponds to one article. The handling time comprises all activities needed to handle an article including inspection and correction activities.

- Quality can be measured by the average outgoing quality. This average outgoing quality is the percentage of orders in which one of the picking errors mentioned above occurs after completing the picking process. Thus, the occurrence of errors is not synonymous with a loss of quality. The indicator of quality is rather the number of errors, which are caused by the picking process but not detected by

inspections and accordingly not corrected. Errors which are recognized during the picking process lead to corrections and have negative effects on the picking performance but do not affect the picking quality.

Appropriately, the regarded picking strategy does not necessarily increase picking performance and decrease picking quality. Another factor that is more important determines how strong the target figures are affected: The degree of inspection. If there are many inspections integrated into the picking process, the quality can be kept on the same level despite increasing errors. Nevertheless, in this case the additionally caused errors will reduce the performance of the system. So, additional inspection and correction activities can cancel out the advantage of reduced travel time. By using Multi-Order-Picking as an example this will be explained in detail:

To work on several orders at the same time means extensive impacts on the whole picking process. As explained, the main intention while transferring such picking strategies is to reduce travel time. Although the parallel order-processing is attended by the already described complexity growth on the part of handling items when retrieving from stock and depositing to order-related picking bins. At this point, a first direct effect on the handling time, which is increased due to this complexity growth, can be identified. Additionally, the modified storage situation results in storage errors and causes different effects on target figures which depend on the intended inspection activities. If a comprehensive amount of inspection is planned, the increase of achievement reached by travel time therefore stands in opposition to reduction in productivity caused by increased handling time due to correction activities for detected errors. Nonetheless, the outgoing quality of the process remains largely unchanged. Just an insignificant unavoidable quality loss will occur due to still undetected errors. If only a low inspection effort is planned, the situation is different. In this case the higher complexity of handling processes when having increasing batch amounts finds direct expression in a reduction of picking quality. It is to assume that a large percentage of errors will be undetected and so will have a negative effect on the average outgoing quality while handling time is mainly unaffected.

This situation is illustrated in a strongly idealized way in Figure 4. The effects of increasing batch amounts depending on the inspection effort are shown on qualitative terms:

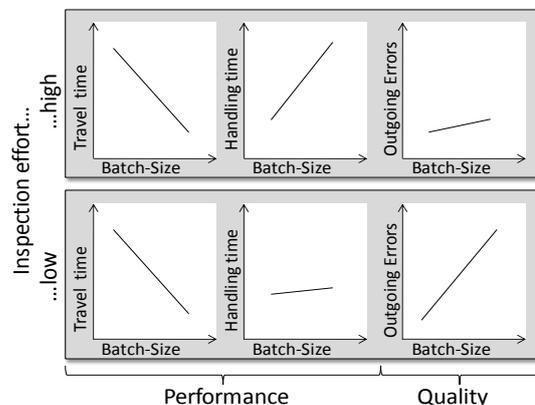


Fig. 4: Correlation between Target Figures and Inspection Effort

5. SIMULATION APPROACH

To make statements concerning exact weightings of single effects is only possible when having a concrete application. In order to quantitatively assess the individual effects and to provide such a statement about the actual increase or decrease of performance and quality, a simulation approach was developed. This approach makes use of two different simulation tools. While the simulation of travel time required the spatial mapping of picking routes and layouts, which was achieved by using Automod simulation software [4], the simulation of handling and inspection activities required a time-discrete and process-oriented approach provided by Arena simulation [5].

With each software a different simulation model was build up considering different target figures. As the Automod simulation was used to model travel time, the only criterion to rely on is the performance of the picking process with travel time per order item as measuring unit. The quality remains unaffected. The Arena simulation was used to simulate the actual picking activities. With it, it is necessary to consider quality in addition to performance, as during these picking activities errors are caused, detected and corrected. Both performance and quality are affected. The corresponding measuring units are average outgoing quality and the handling time per order item.

In Figure 5 the target figures are considered within simulation tools.

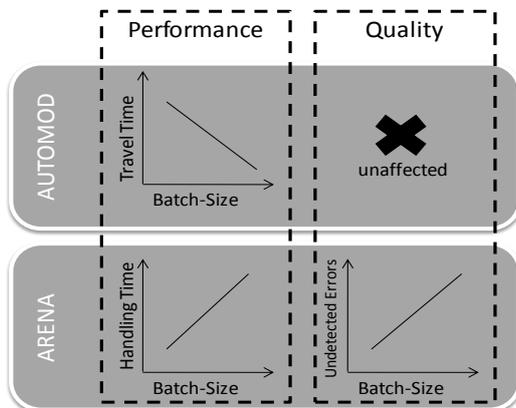


Fig. 5: Target Figures and Simulation Tools (Multi-Order-Picking)

Obtaining concrete results concerning the target figures, the user has to transmit certain input data to the simulation tools (e.g. warehouse characteristics, order structure, article structure, etc.). Based on established methods these data are transformed into time and error probabilities, which are used by simulation tools to proceed the simulation runs. The simulation software calculates specific values and enables the user to estimate the effect on all target figures when implementing an inspection strategy and to understand the overall impact of his decision.

6. CONCLUSION

Already existing researches concerning the application of picking strategies pursue a unilateral objective. Under the

principle of reducing travel time, the other consequences of those strategies have been neglected. For meeting the goal of a more holistic approach a simulation method was developed and presented in this paper. This method integrates the aspect of quality and thus goes beyond the existing simulation approaches.

In table 1, the proven effects associated with the application of the considered picking strategies and the occurring conflict between the competing target figures are illustrated qualitatively. It makes clear the need for a holistic approach as otherwise there is a risk of wrong economic decisions:

Table 1: Effects of implementation of regarded picking strategies depending on inspection effort

			Inspection effort...		
			high	medium	low
Effects	Performance	Travel time	↓	↓	↓
		Handling time	↑	↔	↔
Quality	Outgoing Quality	↔	↔	↓	

Using the simulation method allows quantifying the depicted effects exactly. The user is thus in a position to estimate the overall consequences of the implementation of picking strategies and to plan inspection activities simultaneously if necessary. He can decide on basis of a holistic view by weighting all consequences carefully.

In this context, the only difficulty is the comparison of different types of target figures. While contradictory trends concerning performance can easily be set off against each other due to similar measuring units, this is not possible in case of quality.

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