

Distribution Operations Improvement in the Post-pandemic New Normal: A Case Study

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Abstract

We study the distribution operations in a manufacturer of engines and chassis components. The covid-19 pandemic changes the environment where it operates: demand is more dynamic; the workforce is more limited; product mix is more complex. We investigate the inventory management and material handling in two storage areas - the finished "saleable" items and the bulk racks - to understand the change in demand, stock level, order picking, and slotting caused by the covid-19 pandemic. Insights are generated to inform operations improvement measures that have increased efficiency and saved time and costs. Successful practices and lessons learned will be discussed.

Keywords

Inventory management, Stock level, Operations improvement, Warehouse

1. Introduction

Material handling is a simple concept, but in actual practice, it is extraordinarily complex. Material handling in the distribution center consists of various processes such as receiving, put-away, order picking, assembly, packing, shipping, etc. According to Bartholdi and Hackman [1], order picking is the most labor-intensive activity, which takes 70% of the time and accounts for about 55% of the total operating cost. The covid-19 has had a significant impact on the demand and workforce results in pressure on the organizations to make the warehouse more efficient.

This case study is based on a project we completed with an engine and chassis component manufacturer. The name of the company is not disclosed because of the non-disclosure agreement. The company is a manufacturer of internal engine components for automotive, heavy duty, industrial, agricultural, marine and performance applications. The company is uniquely positioned to deliver the components needed in dozens of nations around the world. The distribution center included in this case study stores engines and chassis components. We consider the order picking from the fast pick area (finished good bins) and bulk area. We analyze the change in order picking patterns due to dynamic demand in both storage areas. To reduce the cost of the distribution center and decrease the time required to retrieve the items, careful allocation of the items is necessary. In this study, a general analysis of the location of the fast-moving and slow-moving items in the distribution center is carried out. Allocation of the items is done based on a change in demand and the number of orders per year.

2. Problem Statement

During the covid-19 pandemic, it was observed that the time required for order picking is more than expected as order picking frequency from the bulk area is increased than forward pick area, which results in the increase in travel distance and cost of handling. It means that the overall process time of the order is increased, which sometimes result in delay in delivery and cancellation of the orders. It was observed that the locations in the forward pick area that are away from the outbound of the distribution center have higher pick frequency compared to the locations that are close to the outbound of the distribution center. Finished good bins have calculated restock level based in last three weeks demand. For many items, the order quantity was always higher than the restock level of the finished good bins. Therefore, those items should always be picked from the bulk area; still, those items were assigned to the finished good bins.

3. Background

Distribution center operations include receiving and unloading inbound materials, putting them away into appropriate storage locations, picking the required materials based on customer orders, and dispatching them to the customer. If any of these operations is inefficient, the overall productivity of the distribution center will be impacted.

In this case study, we consider the distribution center, which houses finished items, i.e., items in saleable form and in non-saleable form. Non-saleable items need to assemble after receiving to make them saleable. Materials are received by the warehouse from various suppliers around the world and then put away into storage locations. These locations include high racks in the bulk area, where received saleable and non-saleable material gets stored. To make order picking more efficient, it is beneficial to separate the bulk storage (reserve area) from the picking stock (forward pick area). Forward pick area (finished good bins) is replenished from bulk racks according to the demand. In general, parts with higher demand are assigned to the locations near the outbound of the distribution center, and parts with low demand are assigned to the locations far from the outbound of the distribution center. This storage policy is because order picking is a time and cost-consuming operation. Figure 1 shows the layout of the Finished Good Bins, having 9 aisles with 4121 storage locations.

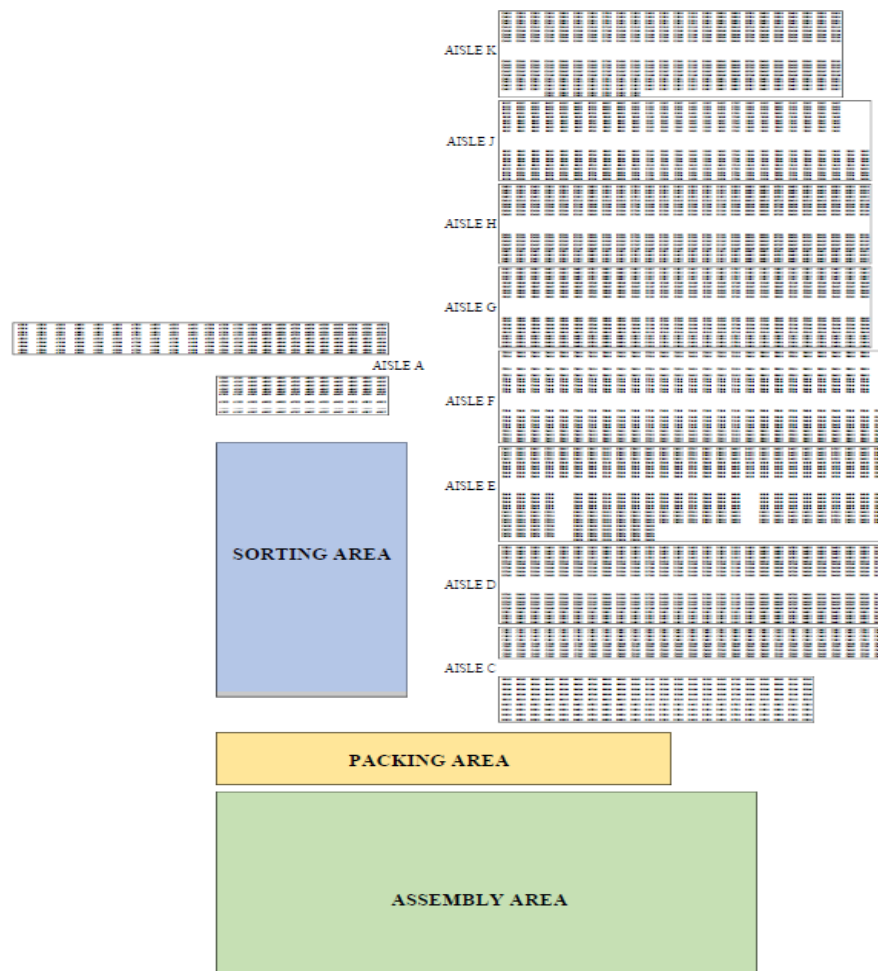


Figure 1: Layout of finished good bins

4. Approach

To see the distribution of order picking, heat maps have been constructed for 2019, 2020 and 2021. It was important to see the difference in activity before the covid-19 pandemic and after. Figure 2 shows the heat map of finished good bins, which shows the frequency of order picking in 2021. Each location was tracked for picking frequency. Red areas show the locations where there has been high amount of order picking activity. The shades of pink to cyan color shows descending levels of order picking activity, whereas white color shows unpicked locations. Developing a heat map is

a crucial step to understand where the picking activity is more, i.e., where the workforce is concentrated. We observe the following based on the heat map:

1. A high concentration of red appears in the aisles K and J, which are away from the sorting station.
2. A generous portion in the finished good bins is in light color (cyan), meaning that order picking is very light in this area.
3. Many locations are in white color, which means there is not any picking history from these locations.

To use the locations in the finished good bins effectively and efficiently, it is necessary to allocate items to the location based on their demand. From this primary analysis of heat maps, "Hot bins" and "Hot parts" were identified. "Hot bins" are the bins having high pick frequency, and "Hot parts" mean the parts having high demand. Hot parts can be relocated to the nearest locations to the sorting station to reduce travel time.

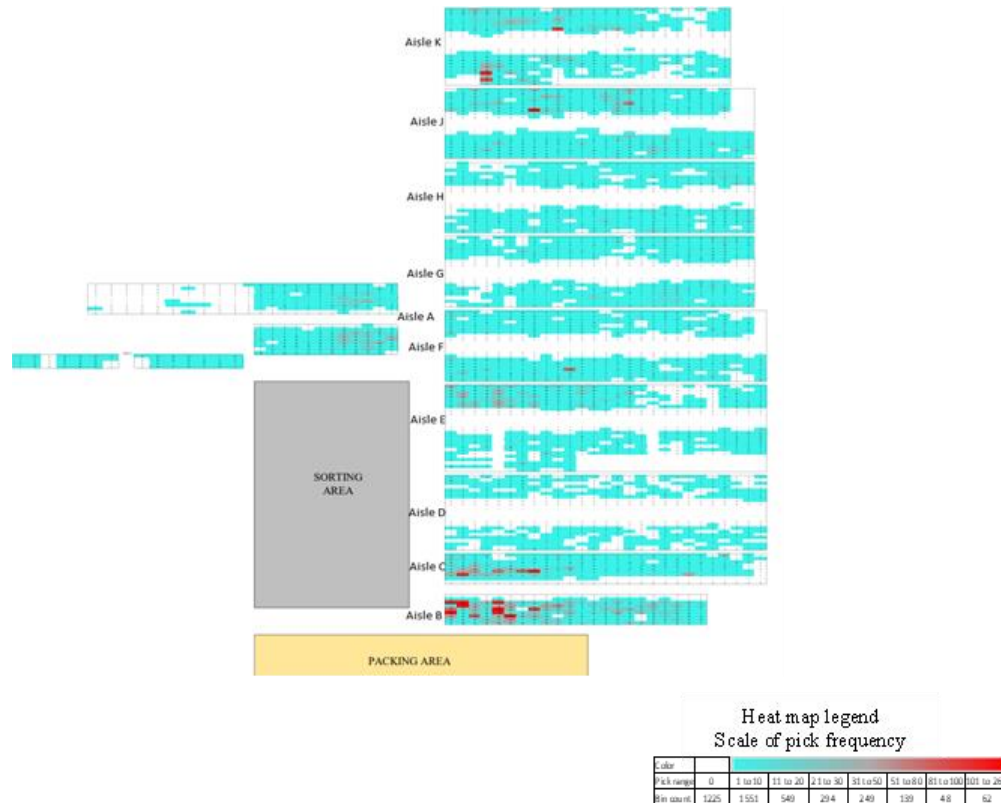


Figure 2: Distribution of order picking in Finished Good Bins

The primary purpose of picking rate change analysis is to see the frequency of order picking from the fast pick area and bulk area. Due to dynamic demand, it was observed that the operation of order picking was disturbed. The majority of parts are picked from the bulk area directly instead of picking from the finished good bins. The distribution center was not getting enough time and resources for restocking the finished good bins. To investigate the order picking trend before and after the pandemic, we used picking history data of 2019 and 2020 of the bulk area and finished good bins. Figures 3 and 4 show the distribution of monthly part picking rate in the year 2020 vs. 2019. Some observations are:

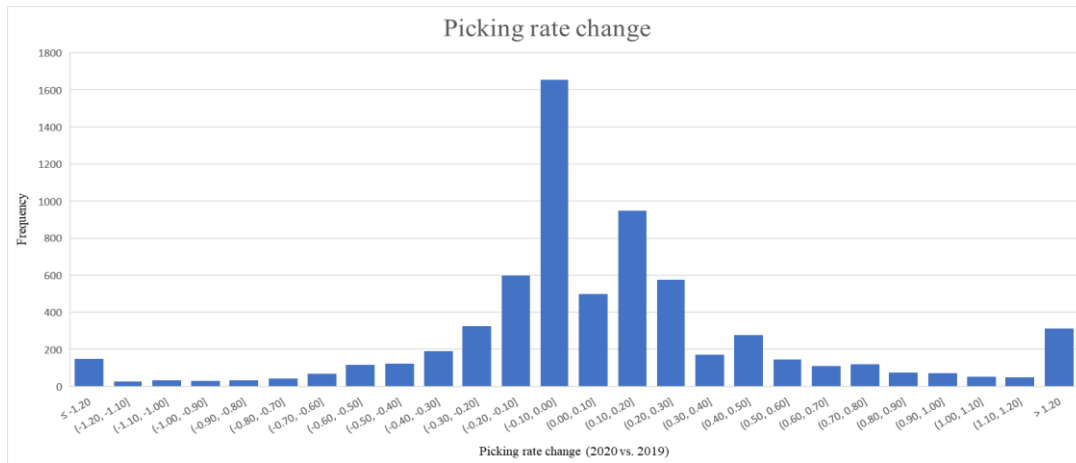


Figure 3: Picking rate change (2020 vs. 2019)

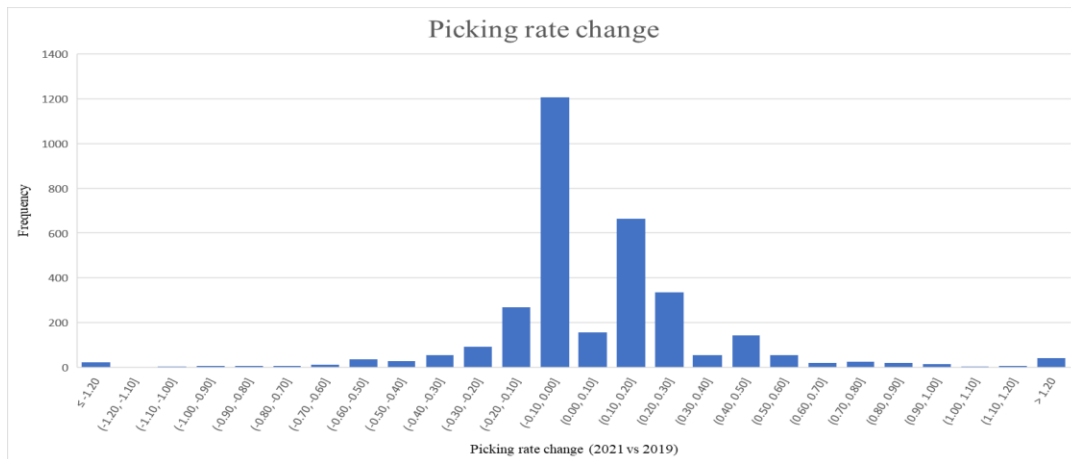


Figure 4: Picking rate change (2021 vs. 2019)

- Total number of parts picked from the finished good bins in year 2019 and 2021 = 6788
- Total number of parts picked from the bulk area in year 2019 and 2021 = 3291
- The total number of parts has a significant drop-off finished good bin-picking rate in 2021 compared to 2019 and has a significant increase of bulk-picking rate in 2021 compared to 2019 = 341.
- 11.87% of parts in finished good bin are picked more frequently in the bulk area in 2021

There are a few possible reasons why workers are picking parts directly from the bulk area. Customer orders could have quantities that are larger than the quantity available in the finished good bins when picking. This would result in the system directing the worker to perform one pick in the bulk area instead of depleting the inventory in the finished good bins and picking the remaining in the bulk area. It was observed that there has been irregular replenishment of the finished good bins due to labor shortages and high picking activity in general. For some bins, it was also observed that the restock level was less than the average order quantity. This could be due to more recent changes in demand, and the restock level weren't updated to a larger restock level.

To investigate this further, we studied restock level calculations and compared restock level of the finished good bins with order quantity. If the restock level is always less than the order quantity, then those parts cannot get picked from the Finished good bins and vice versa.

5. Solution

Analysis to determine parts that should be in Finished Good Bins: To minimize travel time and distance of order picking, we identified the parts that can be added to the Finished Good bins based on their order quantity, change in demand, and a number of orders. While assigning parts to the Finished good bins we gave high priority to parts that:

- are ordered more frequently
- have 50% or more of the orders with quantity < restock level
- have a higher annual order quantity
- have increased demand in 2021 than 2020

Following steps are followed to determine which parts should be in the Finished Good Bins.

Step 1: Prioritize parts by a number of orders:

For this analysis, parts are grouped based on their number of orders. The below table shows the grouping of the parts based on order. Parts having the number of orders greater than 100 were the priority for the analysis. The total number of parts in order data was 7354, shown in Table 1.

Table 1: Prioritization of parts based on number of orders

	No. of orders	Category	No. of parts	% of total parts	Priority
Group 1	101 and above	High	214	3%	1
Group 2	6 to 100	Medium	3680	50%	2
Group 3	1 to 5	Low	3460	47%	3
Total			7354		

Step 2: Comparing order quantity vs. restock level of the Finished Good Bins:

In this step, each order quantity of the parts in group 1 and group 2 is compared with the restock level of that part in the Finished Good bin. For the following analysis, parts having more than 50% of the orders less than restock level were considered, shown in Table 2.

Table 2: Comparison of order quantity with restock level

	Group 1	Group 2	Total
Total number of parts	214	3680	3894
Parts having more than 50% of the orders are less than restock level	211	1972	2183

Step 3: Order quantity and demand change:

Further parts are divided based on order quantity and demand change in table 3. Parts have order quantity greater than 200 considered as high order quantity while parts have order quantity less than 200 considered as low order quantity.

Table 3: Dividing parts based on order quantity

	High in 2020	Low in 2020	Total
High in 2021	899	220	1119
Low in 2021	61	1003	1064

For demand change, the demand of the parts in the year 2020 and the year 2021 is compared. Table 4 shows the number of parts has increased and decreased demand in 2021.

Table 4: Dividing parts based on the change in demand

Demand change	No. of parts
Demand increased in 2021 vs 2020	1590
Demand decreased in 2021 vs 2020	593

Step 4: Prioritization of the parts is based on order quantity and change in demand.

Parts are divided into four cases based on the order quantity and change in demand, shown in Table 5. Parts having high order quantity with increased demand are in the case, having first preference while assigning locations in the Finished good bins. While parts having low order quantity with decreased demand (case 4) are on the last priority.

Parts in case 2 and case 3 have intersecting criteria; parts in case 2 have high order quantity, but the demand is decreased over two years. Parts in case 3 have low order quantity with increased demand. Table 5 shows the number of parts in each case, and color-coding from red to green shows priority from high to low.

Table 5: Prioritization of parts based on order quantity and change in demand

Case	Order Quantity	Change in demand	Total number of parts	Group 1	Group 2
1	High	Increased	842	136	706
2	High	Decreased	277	41	236
3	Low	Increased	748	18	730
4	Low	Decreased	316	16	300
Total			2183	211	1972

Legend:

Color			
Priority	High		Low

6. Conclusion and Final Thoughts

This work presents a real case study to improve the performance of order picking in an existing distribution center. The main objective is to assign parts in fast pick are in order to reduce overall picking time. Due to the covid-19 pandemic, the overall demand of parts changed drastically across three years. Some parts were no longer in demand and there were also new parts that only existed starting in 2020 or 2021. Therefore, it was necessary to reevaluate the current assignment of parts to the finished good bins. In particular, much attention had to be focused on parts that drastically increased in quantity. These parts had to be picked from the bulk area because the finished good bins only had limited capacity. The analysis in the case study focused on finding the parts that should remain in the finished good bins and have higher priority on the most convenient locations. After applying changes based on the analysis, picking time is reduced, resulting in a reduction in overall processing time.

References

[1] Bartholdi, J. J., & Hackman, S. T. (2017). *Warehouse & Distribution Science*. Atlanta, USA.