Differences in the Throughput Performance of the Warehouse Depending on the Quality of the Calculation Parameters

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Objective

The primary goal of our research is to explore the quality level of the parameters that are used to determine the throughput performance of the warehouse. In our model case, this is a rack warehouse where the storage and picking of goods is ensured by forklifts. All kinds of goods are stored on pallets. The aim of our research is to assess to what extent the quality level (accuracy) of the description of warehouse processes influences the accuracy of the determination of the throughput performance of the warehouse. The attention is paid to the value of the difference in the results in the determination of the throughput performance assuming the different quality of the description of the warehouse processes. In particular, the relationship between the significance of the difference and the difficulty of obtaining exact parameters with a higher level of quality level is investigated. By comparing the level of process description quality, it is also possible to identify the parameters that influence the accuracy of the throughput performance more closely.

Background

In order to determine the permeability of the warehouse, it is necessary in this case to determine the time for which the pallet is picked up or stored on its storage position. By this time, it is possible to determine the total amount of pallets can be processed during work shift or during another period. Pallet handling time is expressed as the sum of the time needed to perform partial tasks.

\[
T_r = t_m + 2t_l + \gamma_d \Delta t + 2t_i + \gamma_f \Delta t + t_{mf}
\]

\[
T_r = t_m + 4t_i + \gamma_d \Sigma t_{lu} + 4t_i + \gamma_d \Sigma t_{ld} + t_{mb} + t_{mf}
\]

Other parameters can be add to refine processes description:

- cornering passages \(n_c \Delta t_c\)
- crossing of the junctions \(n_M \Delta t_m\)
- waiting at the junctions \(\Delta t_{es}\)
- time of lifting or lowering the forks \(t_{fU}\) and \(t_{fD}\)
- overtaking in aisle \(\Delta t_{o}\)

\[
T = T_r + n_c \Delta t_c + n_x \Delta t_{xp} + \Delta t_{kx} + \Delta t_{lb}
\]

To carry out the measurements, it was first necessary to construct a measuring device (accelerometer). An as optimum with regard to accuracy and cost, the Arduino development platform was selected to which the ADXL 345 accelerometer module was attached. This module includes a three axis accelerometer. In our case, only to measure the acceleration in the direction of the longitudinal axis of the forklift is needed. Values for the other two directions were not recorded. A module for connecting a SD card was also connected to the Arduino platform. The measured values were stored in a text format on a memory card, and later were processed on the computer.

Results

In the following section, model calculations are made for the total time required to pick up one pallet. Individual parameters are added to each calculation to refine the result. For the model case, the total path from the depot to the storage position and back to 260 m was determined. The maximum speed the carriage moves is 3.8 m/s. If we consider the immediate maximum speed of the forklift, the driving time for the given distance is about 68.4 seconds. This time is taken as a starting point for further comparison. With an acceleration of 1.2 m/s² and a deceleration of 1.5 m/s², the resulting time will be 71.3 seconds, which is 2.9 seconds more than the calculation without the acceleration considered. This time difference is not dependent on the total distance.

<table>
<thead>
<tr>
<th>Type of calculation</th>
<th>Trip time [s]</th>
<th># of pallets</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>simplified</td>
<td>68.4</td>
<td>387</td>
<td>-</td>
</tr>
<tr>
<td>+ acceleration only</td>
<td>71.3</td>
<td>372</td>
<td>- 4 %</td>
</tr>
<tr>
<td>+ lower speed in turns</td>
<td>81.3</td>
<td>329</td>
<td>- 15 %</td>
</tr>
<tr>
<td>+ delay on crossway</td>
<td>83.8</td>
<td>320</td>
<td>- 18 %</td>
</tr>
</tbody>
</table>

Conclusion

These results show that a detailed description of all the processes that take place in the warehouse is important for determining the permeability of the warehouse. In some cases, it is possible to use a certain degree of simplification and omission of some parameters, but the resultant storage permeability may be more or less distorted. It is also important to set the values for each parameter correctly (e.g. based on direct measurement). All of the parameters listed in this article should be included in the calculation of warehouse throughput by computer simulation. Thanks to this, other factors can be included in the calculations to obtain more accurate results. The parameters listed here should form the minimum basis for calculating of warehouse throughput.