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NEW DEMANDS ON AUTOMATED LOGISTICS SYSTEMS Error! Bookmark not defined. TO BE MET BY NEW STRATEGIES

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USUAL COMPUTATION OF THE THROUGHPUT OF AUTOMATED MATERIAL FLOW SYSTEMS

The max. throughput of material flow systems achievable for a short time can be calculated easily in the analytical way. If permanently obtainable system throughputs are required, it can be stated from experience that a throughput value amounting to approx. 50 % of the max. value obtainable at a bottleneck can definitely be achieved as system throughput.

If higher values are required, it is to be investigated in detail to what extent accumulation functions are necessary before and after branches and merging points, which fluctuations of performance occur, etc.. Manual activities within systems (e.g. order picking) or also charging of systems and/or discharging may be subject to other influences and fluctuations. The more one approaches theoretical max. values the earlier it could be necessary to investigate the expected system behaviour by simulation.

The above statements do not consider any influences of the operational sequence organisation actually provided. They are based on an equal distribution of throughput values to sources and sinks. This only insufficiently reflects the situation in practice and could lead to wrong results. In manually operated material flow systems it is often possible to conceal consequences of wrong assumptions and imperfect planning. For example, in stacker-operated systems the "installed throughput values" can be relatively flexibly adapted to the actual requirements (as long as one remains below the max. values obtainable from the system) by using additional stackers or reducing the number of stackers.

In most cases, automated systems do not "excuse" planning errors. Overdimensioning tends to results in uneconomic systems, underdimensioning can be "fatal".

Since we are increasingly faced with the task of connecting internal automation islands, great importance is to be attached to the recognition of imperfect planning, especially to possible consequences when coupling previously uncoupled automated systems.

These problems will be explained on the basis of a simple example of high-rise warehousing technology.

THROUGHPUT CALCULATION OF HIGH-RISE WAREHOUSES

The throughput is normally calculated on the basis of FEM (Féderation Européenne du Manutention) Guidelines. The cycle times actually required in practice considerably vary with regard to FEM values for single cycles and combined cycles. Depending on type of charging/discharging of load units in a high-rise warehouse, buffer places are required before the aisles to at least partly compensate for the deviations from the mean value.Gudehus has already proved that the actually achievable throughput is clearly under the value computed on the basis of FEM Guidelines. With 3 buffer places, one normally assumes about 85 to 90 % of the values computed.

This method is applied on the assumption that all storage locations are most probably served alike and that all articles are stored in almost equal quantities with equal picking frequency. This assumption is unrealistic. We even use the effect of the ABC distribution shown to create fast mover zones (resulting in increased throughput).

Common operating strategies for storage in a multi-aisle warehouse take any consequences of a possible failure of individual storage and retrieval machines into account (crosswise storing, uniform utilisation of machines, uniform utilisation of storage locations, etc.). The FIFO strategy is applied when performing retrieval.

The structure of customers' orders or orders for assembly which entail retrievals normally remains completely unconsidered.

NEW DEMANDS

JIT supply to assembly lines (e.g. in automobile industry) is to provide that the parts are supplied in exactly the same order as required by manufacture planning.

When supplying supermarkets with goods, the delivery trucks are to be loaded in accordance with the orders obtained from the individual supermarkets in that the succession of the load units within an order is not necessarily to be subject to a strict sequence.

If shuttle trucks between warehouse and JIT assembly and/or delivery trucks for the supermarkets stated are automatically loaded with the goods desired from a high-rise warehouse by coupling the automatic warehouse with automatic loading, the expected throughput of the coupled system is $\text{throughput}_{\text{couples system}} = \text{Min}\ \{\text{throughput}_{\text{loading system}}, \text{throughput}_{\text{warehouse system}}\}$.

This assumption proves to be wrong for coupling with multi-aisle high-rise warehouses.

SIMULATION OF COUPLED SYSTEMS

Fig. 1 shows that the achievable throughput of high-rise warehouses with retrievals at a predetermined order (corresponding to the specifications of the coupled loading system) and depending on the number of buffer places in a 10-aisles warehouse is reduced to approx. 65 to 85 % of the value without predetermined order.

If only customers' orders of a determined sequence are handled - however with the load units arranged at will within the order - the result changes negligibly (Fig. 2).

Fixed quantities for such orders or also distributions with differently big orders (Models 1 and 2) have been specified for a 10-aisles warehouse. Only one buffer place (for example) shows negligible effects on the throughput (Fig. 3).

Since it is to be taken into account that at least "islands of automation" are coupled and especially automated loading of trucks in combination with automatic warehouses proceed to develop, the aforementioned results have been published. This immediately involved a first test in practice.

AUTOMATIC MINILOAD WAREHOUSE OF DAIMLER CHRYSLER, SINDELFINGEN PLANT

Historically grown, the plant included a number of different warehouses for small parts which were intended to be combined to an automated 10-aisles warehouse to supply the assembly places for Daimler S and E types with material at a 30 minutes rhythm. 4 tractors with several carriages have been provided for this purpose:

3 tractor units: 4 carriages with max. 24 VDA containers
1 tractor unit: 5 carriages with max. 24 VDA containers

Since 16 containers per carriages had to be taken into account on an average, this resulted in 272 retrievals/30 minutes, referred to the individual storage and retrieval unit 54.4 retrievals/h as mean value and 81.6 retrievals/h as peak value. The carriages of the tractor units had to be loaded automatically, i.e. in exactly the same sequence as the disposal places in the assembly area (1st container of the 1st carriage for the 1st disposal place, etc.).

The warehouse was planned without knowledge of the correlations described before.

Storage and retrieval units with 2 load carrying devices each for VDA containers have been provided. 32300 storage locations for containers of 380 mm height and 44200 locations for 240 mm high containers have been installed. Storage of even 2 containers of smaller bases in one compartment has been permitted.

Further boundary conditions have been added. Determination of cycle time according to FEM resulted in 60.9 combined cycles/h for machines with 1 load carrying device and in 83.8 for two load carrying devices. Simulation of orders for retrieval without predefined sequence produced values ranging between 828 and 842 containers/h.

If the conditions for loading tractor units have been considered (4 loading stations as major goals, 17 carriages as sub-goals), retrievals reduced to 586 containers/h (2 buffer places) or 664 containers/h (4 buffer places) or 691 containers/h (6 buffer places) due to the problems of sequence. Even on a completely unrealistic assumption of 16 buffer places, throughput losses of 7 % had still to be considered.

Apart from economical aspects, the dimensions of the warehouse could not be modified at will which resulted in a search for strategies to meet the sequences specified without such significant throughput losses. When considering the usual ABC distribution and actual stacking, several containers including one type of article are often supplied "simultaneously" and booked successively by the computer system. When deviating here from the FIFO principle one could choose <u>the</u> location for discharge from the different locations of one type of article which has the least negative effect on the throughput. As to the example of the DaimlerChrysler warehouse, this strategy provides, on the assumption that any discharge point determined by FIFO includes a random alternative, a throughput decrease of only 3.5 %. With the actually existing ABC distribution and realisation of the new strategy described, a loss of approx. 6 to 8 % is to be expected. In the presence of normal reserves in the planning process (peak loads, integer number of storage and retrieval machines) any replanning involving additional investments could be avoided thanks to the introduction of this strategy.

Without investigation by simulation and without a change of strategy, nonfulfilment of planned throughput values presumably would have been recognised very late and the reason for it most certainly referred more to mechanical and control aspects than to retrieval strategy.

SUMMARY

New requirements or only the coupling of known systems might involve unexpected reductions of planned throughputs. Common considerations on dimensioning disregard influences of actually implemented sequences. For this reason, it is indispensable to also include sequence organisation in addition to known rules.

This leads to new strategies which contribute to compensation for losses in throughput but also to increase in throughput (e.g. of sorters, check-in systems on airports, distribution from one source to many sinks).

In conclusion I should like to present a picture showing the collision of a storage and retrieval machine in a high-rise warehouse which uses the usual strategies. Without own restart strategy after failure, the throughput initially continues to decrease further after completed collision (time t2) until (from time t3) the pre-collision condition is gradually established again.

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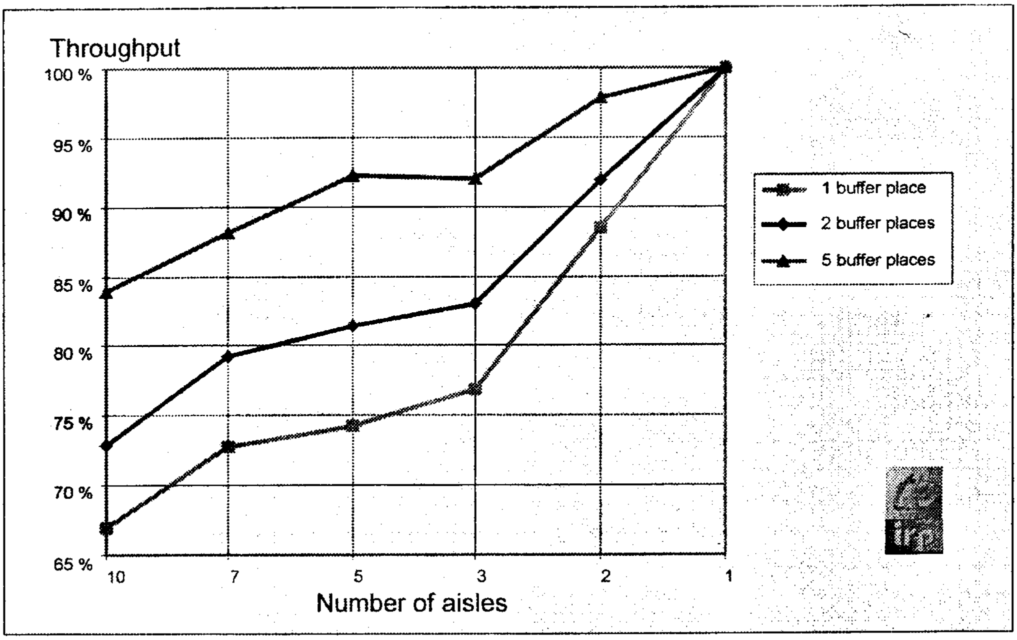

Fig. 1: Reduction of throughput by a given sequence of retrieval orders

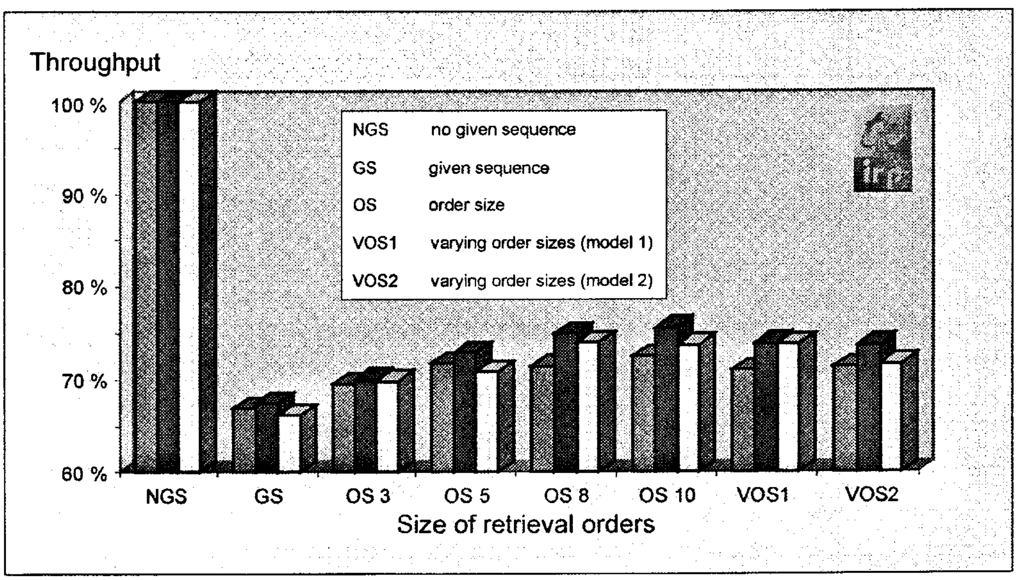

Fig.2: Throughput as a function of buffer places available in front of aisles

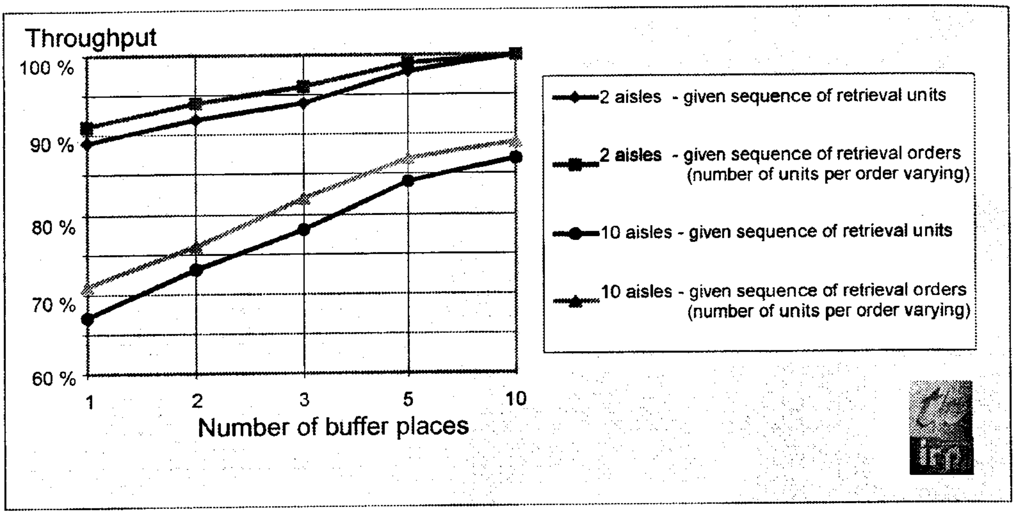

Fig. 3: Possible throughput as a function of order sizes (10 aisles, 1 buffer place)

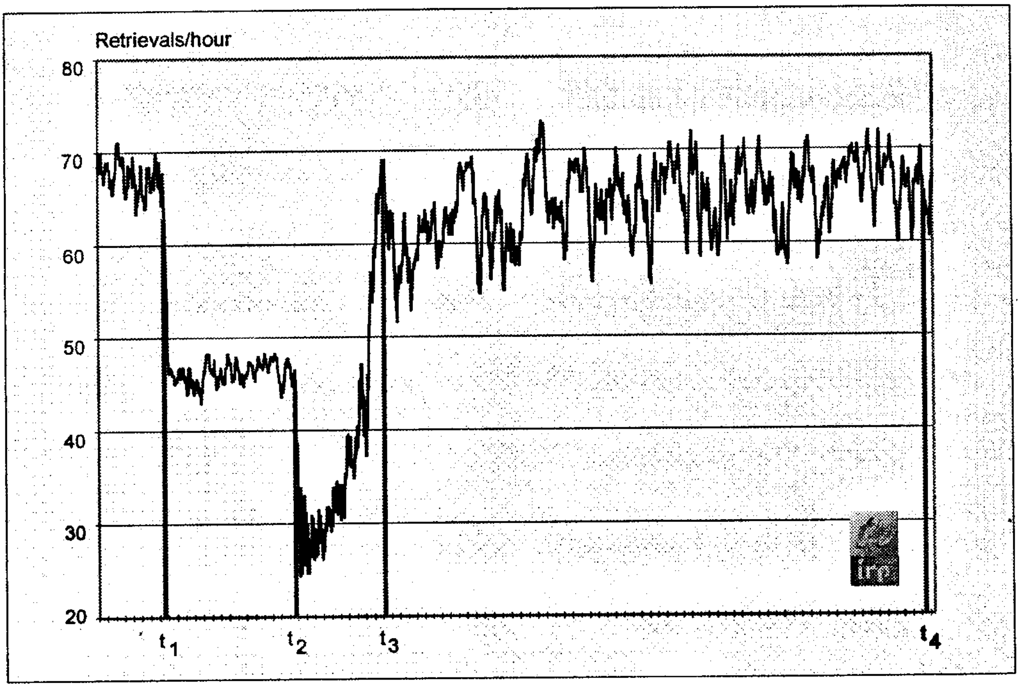

Fig. 4: Collision of 1 (out of 3) AS/RS – units for the time t_1-t_2