4/12/2018

Designing the inbound warehouse process

Master thesis - Public summary

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PUBLIC SUMMARY

In order to complete the master Industrial Engineering & Management (specialization: Production and Logistic Management) at the University of Twente I performed a research study for my final assignment.

In this research I studied an industrial company, Company X. Company X has decided to build a new warehouse. In this new warehouse it is planned to implement an automated storage and retrieval system (ASRS). The global layout already is determined before, but the company now wants to know how it can design efficient processes for the new warehouse. This leads to the main question for our research study:

Given the global layout, how should the inbound processes in the new warehouse be designed to obtain an efficient inbound process?

This research investigated which changes are needed to the current inbound process to make the process efficient and feasible for the new warehouse. For this, wastes (inefficiencies) in the current inbound processes were identified. We tried to eliminate these wastes when designing the routes for material, processes and a more detailed layout for the new warehouse.

We categorized the found wastes in the following groups:

- Much movement needed

Movement costs time and should be eliminated as much as possible.

- Many transfers needed

Each transfer costs time, but also increases the chance of mistakes. The amount of transfers should therefore be limited.

- Much work in process

Much work in process is also not desirable. This increases throughput times, goods wait longer in buffers. But buffers can also get overloaded if many goods are present in the process. Some goods then have to be stored further away, which leads to more movement.

APPROACH

To design an efficient warehouse inbound process, we used roughly three steps (see Figure 0-1).

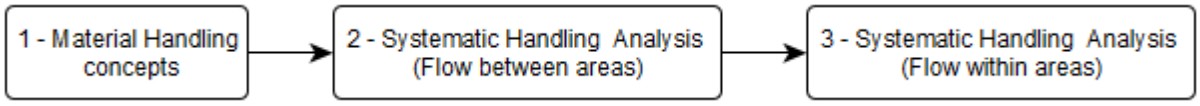

FIGURE 0-1 - THREE STEPS TO DESIGN AN EFFICIENT WAREHOUSE INBOUND PROCESS

Below we discuss each step:

1. **Material Handling concepts**

In this first step we determined which Material Handling equipment is interesting to use for the inbound warehouse process for Company X and which equipment is not interesting to use. In the next steps the chosen concept will be refined.

According to (Kay, 2012) about 37 types of transport equipment are available, which are divided in the categories: Conveyors, Cranes and Industrial Trucks. At Company X, goods arrive at the dock and need to go to the ASRS input area, which is in a different area. This makes Cranes & Hoist not usable in this first part of the incoming goods process. Besides, Cranes & Hoists are most suitable to transport heavy goods (Peters, 1998), which hardly are present in the receiving process.

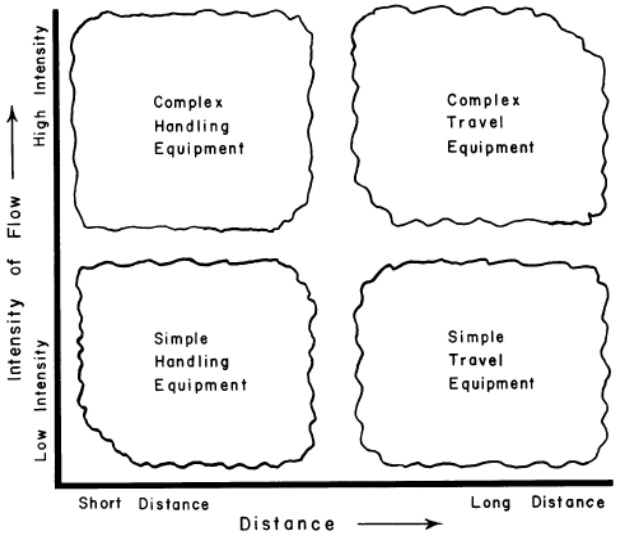

FIGURE 0-2- FOUR CLASSES OF MATERIAL HANDLING EQUIPMENT, BASED ON INTENSITY OF FLOW AND DISTANCE (MUTHER & HAGANÄS, 1987)

We therefore only make some concepts with conveyors or industrial vehicles as transport equipment. Still there are according to (Kay, 2012) 33 options in these two categories, which still is many options to evaluate. We reduced this number further down by working out only 1 concept per class. We based these classes on four general material handling equipment classes based on cost data (Muther & Haganäs, 1987), which are based on the following aspects. Handling equipment has low fixed cost and high travel costs, while travel equipment has high fixed costs and low travel costs. Simple Equipment has low fixed costs and high variable costs, while complex equipment has high fixed costs and low variable costs. Figure 0-2 combines these aspects and shows the four classes in a 2 x 2 matrix.

We generated 1 concept per class. This way we can determine which class of material handling equipment is interesting to use for Company X.

To choose the best concept we used the AHP method. AHP is a multi-criteria decision making (MCDM), which helps to reduce complexity and organize thinking. It is a systematic process that can help determine efficiently the importance of criteria and compare alternatives with different criteria. In our case this the AHP method is good to use, because it handles tangible as well as intangible criteria (P. Cousins, 2008).

We used the following criteria for each concept:

- Investments
- Transportation costs
- Adaptability

Per concept we calculated the score with the AHP method and choose the concept with the highest score.

2. **Systematic Handling Analysis (Flow between areas)**

In the second step we refined the chosen concept from the first step. We used the Systematic Handling Analysis (SHA) method for designing the refined material handling plans. Here, we use the wastes as input for the improvements of the processes. Which results in alternative handling plans for flows **between** areas. We evaluated and improved these plans and chose the best refined plan.

The SHA method consists roughly of the following steps:

1. Classify materials

In the first step material classes are created. These materials need to be handled in the same way, basically. This simplifies the analysis by break down the problem in solvable parts.

2. Analyze & visualize moves

Determine material quantities per route and visualize them in the plan. Analyze these routes and identify potential improvements.

3. Design handling plans

Determine alternative handling plans. Often more than one method per route is possible.

4. Evaluate and select handling plan

Sometimes modifications are needed to the handling plans to make them feasible for practice. The (possibly modified) alternative handling plans are compared to each other based on the following criteria:

- Number of transport actions
- Distances
- Scalability

Eventually this lead to a score for each plan. The plan with the highest score was chosen.

3. **Systematic Handling Analysis (Flow within areas)**

In the second step the areas and transport equipment already was determined. In this third step, details within the area still need to be determined. For the Dock (where goods arrive), we must determine the precise layout and the way the goods will be received from the drivers. For the ASRS area we must determine the precise layout that will handle the flow of goods in the best way. And finally, how to control the throughput time of incoming goods.

MATERIAL HANDLING CONCEPTS

Before we worked out the detailed designs, we first made some concepts based on different type of material handling equipment. Material handling equipment is needed in the inbound process to move goods from one area to another area. The type of equipment affects the inbound process, e.g. are goods transported by a conveyor or by a rolling cart?

We compared four concepts to limit the number of material handling equipment options. Each concept belongs to a different class of material handling equipment. We selected the following concepts for each equipment class:

- 'Rolling cart' concept (class: simple handling equipment)
- 'Train' concept (class: simple travel equipment)
- 'Conveyor' concept (class: complex handling equipment)
- 'Train with Rolling conveyors' (class: complex travel equipment)

The Rolling cart concept scored best based on the criteria Investment costs, Transport costs and Adaptability. The main reasons why this concept scored well were the low investment costs (Company X already has this equipment), short transport distances in the inbound process (e.g. travel equipment gets cheaper if distances would be longer in the inbound process) and it is easy to adapt to possible future changes in the inbound layout (if e.g. Company X grows a lot and the areas need to change, this equipment still can be used easily, while this is more difficult for e.g. conveyors).

Systematic Handling Analysis (Flow between areas)

We looked to the process in more detail knowing that we mainly used equipment from the class "simple handling equipment". We made three detailed Handling plans (with the Systematic Handling Analysis method).

Plan 1 is based on the current processes, but applied (with some necessary changes) to the new global layout. Plan 2 is based on plan 1, but we made improvements based on identified wastes in the current inbound process. Plan 3 is like plan 2, only with one improvement less. We suggest the following 5 improvements for plan 2:

1. Send only small goods to the ASRS

This limits the movement (by employees) needed in this area. In the new global layout, the intake of goods is positioned in the ASRS Area. In the current warehouse the intake area sometimes has too little space to store all incoming pallets, which lead to more movement (pallets need to put further away from the Intake station or needed to be repositioned). The ASRS (in the new warehouse) is even smaller than the current intake area, which would lead to even more problems. Besides, pallet goods are not putaway in the ASRS and can be taken in another area.

2. Unbox small goods simultaneously with Intake

This limits the movement and transfers (handing goods over to another employee) needed. The unboxing process, currently done at a separate work desk, can be combined with the Intake of goods. This way, small goods need less handling, by different employees, and can be transported directly from the Dock to the intake employees.

3. Do the intake of pallet goods on the Dock

This limits the transfers and movements of the employees. The new Dock is larger than the old Dock and can contain as much pallets as in the current Intake area. A temporary buffer close to the Dock can also be used if temporarily more space is needed for the pallet goods. This way, the Intake employee for pallet goods can do the intake of pallet goods without first transporting the pallets to another area (most of the time). After intake an employee on a reach truck gets automatically a signal

(on a terminal on his reach truck) to retrieve the pallet(s) on the Dock and can bring it directly to its destination.

4. Send floorstock (anonymous goods) directly to the VLM (Vertical Lift Module).

This limits the transfers and movements of the employees. Goods go in less process steps from Dock to their stocking destination. These goods can skip the ASRS Area.

5. Use a general cart (put goods for different destinations on a single cart)

This limits movements of employees. In the new warehouse, most small goods go to the ASRS. Only a little amount goes from the ASRS Area to other destinations. These goods can be combined on a single cart, this way the employee only has to walk to the other destinations in one run.

Plan 3 has also most of these improvements, but without the improvement 3: "Do the intake of pallet goods on the Dock" (in case the intake on the Dock seems undesirable for Company X). We compared these three plans:

- Plan 1: Based on the current inbound process, but in the new layout
- Plan 2: As plan 1, but with all five proposed improvements
- Plan 3 As plan 2, only without improvement 3: "Do the intake of pallet goods on the Dock"

Plan 2 scored best and is advised to use in the new warehouse, this was based on the selected criteria: number of transport actions, travel distance and scalability (how easy can the process be adapted to more or less incoming goods). 25% less transport actions are needed, 23% less travel distance per day is needed and this plan is better scalable than the design based on the current way of working.

SYSTEMATIC HANDLING ANALYSIS (FLOW WITHIN AREAS)

Now that we know the Handling plan we zoom in to the Dock and ASRS Area.

We saw that intake of pallet goods should take place on the Dock. The intake time of pallets however appeared to be quite high with an average of 7 minutes per order row (one type of good in an order). Chances are high that drivers (who deliver goods to Company X) interrupt this intake process if these drivers can freely enter the Dock and ask the intake employee to sign for receipt of the goods. Many interruptions for the intake employee on the Dock might lead to mistakes, which is undesirable.

An Intake employee of the ASRS Area should receive the goods, because their intake time is lower with on average 1.5 minutes per order row. On top of that, we suggest receiving all drivers at a Reception desk in a separate area behind the Dock, for the following reasons:

- About half of the drivers do not necessarily need the Dock to deliver their goods to Company X. These are couriers, driving a van and delivering boxes, which also can be delivered through a normal door (which is present in the reception area).
- Intake employees at the ASRS first can finish their order row and then walk to the reception desk (which only is a few meters from their work place).

- The Dock will be a better work place for the Intake employee of pallet goods, because the Dock doors can be held closed (no cold air coming in constantly during cold days) and no distraction from drivers walking in and disturbing the intake process. Dock doors only need to open for couriers with pallet goods (just a couple of times per day) and about half of the times for large trucks (but this results not in cold incoming air, because here a seal is used between the Dock and the truck trailer).

Much goods go to the ASRS Area, therefore it is important that employees can take in these goods without moving much. We suggest placing the input and output destinations close to the work desk to limit the movement needed. Input destinations for this process are "incoming goods" (which are boxes on rolling carts) and "empty totes" (to store goods in). Output destinations for this process are "totes with booked in goods" and "waste bins", see Figure 0-3.

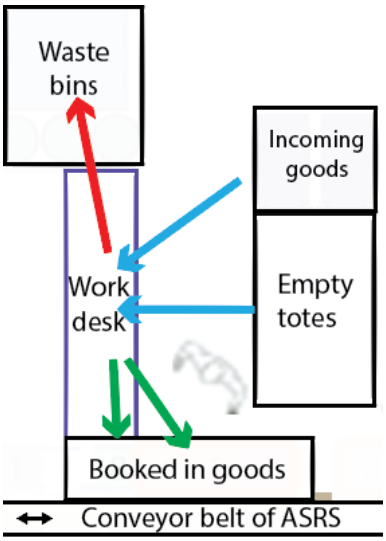

FIGURE 0-3 – ONE OF THE FOUR WORK PLACES IN THE ASRS AREA.

Company X could also make some adjustments to the conveyors of the ASRS (which are behind the booked in goods) for goods that do not go to the ASRS. The conveyors can transport these goods to a separate area next to the ASRS, where goods can be put on a cart and brought to their destinations by another employee. This limits the moves needed for the intake employees in the ASRS Area.

Besides an efficient inbound process, Company X also wants to reduce the throughput time of incoming goods to a maximum of half a day (at this moment this can range between 2 hours and 2 days). We found two ways to control this process. By changing the supply (external) or by adjusting Company X own capacity (internal) based on the present workload in the inbound process.

To improve the supply of goods, we saw that it would be best that drivers arrive evenly over the day (this reduces peak hours) and arrive before 14:00 (this makes it possible to take in goods the same day without overwork is needed for the intake employees). We advise Company X to negotiate with suppliers and couriers to let about 3 drivers arrive per hour at Company X, from 7:00 to about 14:00.

It probably is hard to let drivers deliver goods distributed evenly over the day. For this reason, it is also important that Company X can adjust its own capacity to the number of incoming goods. We propose that the Chief of the warehouse estimates how much work is present in the Intake buffers. He can estimate this by checking the number of rolling carts and pallets at two times during the day. This way he can determine if an increase or decrease of intake capacity is needed. This check is manual, because the information system that Company X uses can't estimate the number goods in the intake buffer. Goods are only visible in the system after the intake of goods.

We now have proposed a way to adjust the capacity if needed, but Company X still doesn't know if goods are taken in within half a day or sooner (which is goal for the inbound process in the new warehouse). An estimation of this throughput time of incoming goods can be made by the Chief of the warehouse. Goods that arrive before the first check, should be taken in when performing the second check (this ensures that these goods are taken in within half a day). During the first check he puts a

sticker on each rolling cart and pallet. During the second check he counts the stickers (goods that are still not taken in) and estimate the number of goods that are taken in too late.

We evaluated at which points in time the Chief could carry out these checks. This depends on if more goods are delivered in the morning or not. If drivers arrive evenly between 7:00 and 14:00, we advise to also check the intake buffers evenly spread over the day. This way the capacity can be controlled best.

Option 1: First check at 10:00 Second check at 13:00

But if the supply is hard to adjust and little goods arrive before 10:00 (like in the current inbound process), checking at 10:00 would not very effective. In this situation it is better to check goods a bit later. We then advise to check goods at the following points of time:

Option 2: First check at 11:00 Second check at 13:30

We therefore suggest the following 4 KPIs to check the performance of the inbound process:

- On time delivery

This KPI measures if drivers deliver goods at the negotiated point of time.

- The number of goods in the intake buffers at the first check
- The number of goods in the intake buffers at the second check

These KPIs indicates if an increase or decrease of the Intake capacity is needed.

- The number of stickered goods in the intake at the second check

This KPI measures how many goods have a throughput time in the inbound process that is too high.

Further research is needed to determine when and how to react on values of these KPIs.

RECOMMENDATIONS

We recommend Company X to carry out the following main steps, which will help to implement an efficient inbound process for incoming goods for the new warehouse.

- **Step 1**, combine unboxing with the intake process. This reduces the movements and transfers needed.
- **Step 2**, let goods be delivered more evenly distributed throughout the day. This reduces peak hours of incoming goods.
    - Identify which suppliers / couriers deliver goods at busy moments or after 14:00.
    - Negotiate with these suppliers / couriers to deliver goods at quieter times.
- **Step 3**, make it possible to split small and large goods on the Dock. Small goods can then be transported directly to the ASRS Area.
    - Identify suppliers that deliver one packing slip for both small and large goods (this makes splitting the goods on the Dock impossible).
    - Negotiate with these suppliers to deliver these goods on separate packing slips
- **Step 4**, make it possible to split floorstock (anonymous goods) on the Dock. These goods can then be transported directly to the Verticle Lift Module.
    - Negotiate with the largest floorstock suppliers to deliver floorstock and project goods separately.

    - Negotiate with the largest floorstock suppliers, make floorstock visible from the outside.
- **Step 5**, improve the parameters for controlling the inbound capacity. These parameters should indicate (based on the number of goods in the Intake buffers) whether it is needed to add or remove an employee in the inbound process.
    - Determine time standards for Rolling Carts (average intake time).
    - Determine time standards for Pallet goods (average intake time).
    - Determine parameters, at which number of incoming goods in the intake buffers it is necessary to increase or decrease the inbound capacity.

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