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Transformation of Aalborg University SmartLab from Reconfigurable Manufacturing System to Matrix Production

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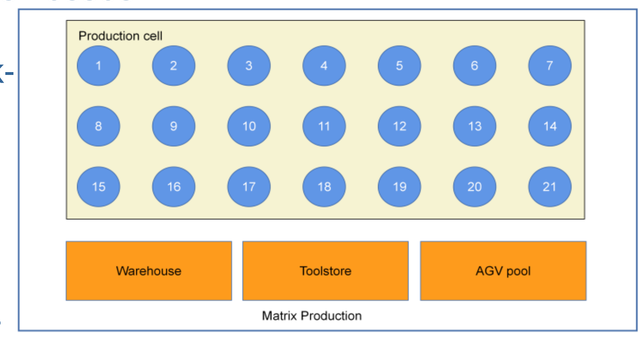
Introduction

In recent years, manufacturers have experienced an increasing demand for production of customised products. Simultaneously, the rapid development of new technologies has led to a demand for flexible manufacturing systems. Matrix Production (MP) is a new promising manufacturing system which shows potential in providing flexibility to manufacturing businesses.

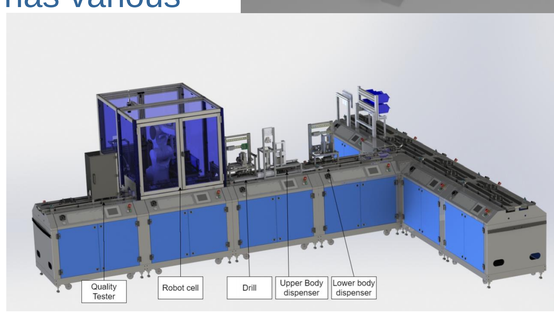
The principle of Matrix Production is to position workstations in a matrix-grid, and have mobile robots transporting workpieces between workstations. This gives flexibility in the form of routing and process reconfigurability. Compared to traditional manufacturing systems, this allows the production to quickly adapt to both foreseen and unforeseen changes.



AAU SmartLab

The objective for this project is to investigate the potential of matrix production by transforming the AAU SmartLab into Matrix Production using Discrete Event Simulation.

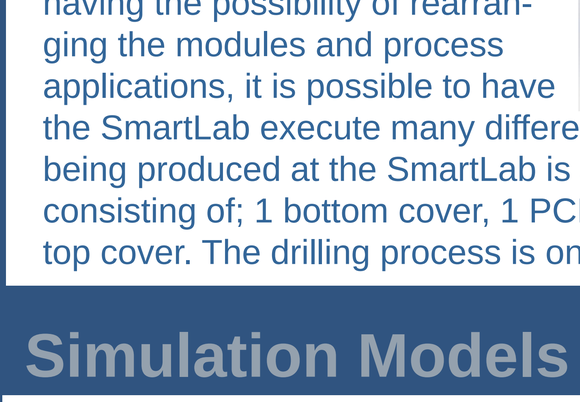
The AAU SmartLab is a module-based reconfigurable manufacturing system (RMS) for research and demonstration. The SmartLab has various process applications such as drilling, assembling and quality inspection, which can be installed on their transport modules. By having the possibility of rearranging the modules and process applications, it is possible to have the SmartLab execute many different tasks/processes. The product being produced at the SmartLab is a "dummy" mobile phone, consisting of; 1 bottom cover, 1 PCB with 2 fuse holders, 0-2 fuses, 1 top cover. The drilling process is only simulated.



Simulation Models

The transformation of the AAU SmartLab is performed using Discrete event simulation in Enterprise Dynamics. The two models are the current setup, *the As-Is*, and the matrix production version*, SLaMP (SmartLab as Matrix Production)*. The SLaMP model uses 1 AMR for transportation with load/unload time of 5 s. Lead times are evaluated for 6 different version of the phone (0-2 fuses and 1-2 drillings) + a 100 product order list.

The As-Is Model



The SLaMP Model

	SLaMP	As-Is
Product 1	3 min, 11 s	2 min, 40 s
Product 2	3 min, 35 s	3 min, 4 s
Product 3	3 min, 38 s	3 min, 7 s
Product 4	3 min, 16 s	2 min, 45 s
Product 5	3 min, 29 s	2 min, 59 s
Product 6	3 min, 43 s	3 min, 12 s
Order list	3 h, 28 min, 32 s	2 h, 0 min, 36 s

The As-Is model has a lower lead time in every case, due to only 1 AMR and a load/unload time.

As-Is versus SLaMP

The direct transformation to matrix production is not an improvement with respect to lead time. Therefore, the product will undergo a change to utilise MP benefits better, taking the form of an extra drilling process. The new test will be measuring a single order with the three different drilling scenarios both when moving through the systems solo and moving through the systems handling other orders as well. A list consisting of 100 phones with the three types of process sequencing randomly chosen for each one will also be tested. To the left is the 3 sequences

	Bottom Cover Drilling	Top Cover Drilling	Both Cover Drilling
1	Bottom cover dispensing	Bottom cover dispensing	Bottom cover dispensing
2	Drilling	Robot cell	Drilling
3	Robot cell	Quality inspection	Robot cell
4	Quality inspection	Top cover dispensing	Quality inspection
5	Top cover dispensing	Drilling	Top cover dispensing
6	Packaging	Packaging	Drilling
7			Packaging

1 Product (Solo)	As-Is	SLaMP
Bottom Drilling	3 min, 12 s	3 min, 43 s
Top Drilling	4 min, 36 s	3 min, 47 s
Both Drilling	4 min, 47 s	4 min, 14 s

1 Product (Order List)	As-Is	SLaMP
Bottom Drilling	3 min, 12 s	4 min, 34 s
Top Drilling	44 min, 32 s	6 min, 5 s
Both Drilling	44 min, 43 s	6 min, 43 s

Looking at how well the systems cope with an individual order when the systems are also processing other orders, there is a significant lead time decrease using the SLaMP model. The 40+ minutes extra time for the "top drilling" product and "both drilling" product corresponds to their mandatory second loop of the system in the As-Is model and because they are being held up by all the other products that are now in front of them on their first loop. However, the As-Is model is still superior, when it comes to handling the 100 product order list. The As-Is system deals with the list in 2 hours and 20 minutes, whereas SLaMP uses almost 4 hours, which is close to a 170% lead time increase.

Order List	
As-Is	SLaMP
2 h, 20 min, 11 s	3 h, 58 min, 12 s

Conclusions

- Increasing the number of AMRs in the SLaMP model gave a shorter Lead Time. With a single AMR available, FIFO strategy performed best. With more AMRs available, single workpiece assignment worked better.
- When introducing product variance, the MP model shows an increased flexibility, and in some scenarios leads to a lower lead time for low volume orders. However, when the volume increases, the As-Is model outperformed the MP model.

In general, the lead times of SLaMP are shorter than that of the As-Is model when producing a small batch of products, with a different process sequence which indicates that MP offers more flexibility than the traditional SmartLab in terms of its routing ability. However, these benefits were very circumstantial, and the arguments for converting the SmartLab to matrix production are very slim with the high throughput of the current system.

The extra load/unload when implementing the AMR leads to lower utilisation of the robot cell and slows down the production of MP. Lower utilisation and longer lead times illustrates that the current structure of matrix production is not suitable for the current AAU SmartLab. More complex processes and more product variants might fully demonstrate the high flexibility of matrix production.

Acknowledgement

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