TKI DINALOG
Dutch Institute for Advanced Logistics

MAINTENANCE PREDICTION

ADVANCE ORDERING SPARE PARTS

Using advance demand information in Océ's spare parts inventory control

Océ is a global leader in digital imaging, industrial printing and collaborative business services and is part of the Canon Group. Two departments are responsible for the availability and delivery of service parts to customers worldwide: the Service Parts 1 department in Venlo and the Service Parts 2 department in Poing. This study is conducted at the former department. We develop a model to apply the information contained in a maintenance planning to improve a spare parts inventory planning. This information is called advance demand information (ADI) and is defined as 'customer orders that are available prior to their materialization'. We focus on the VarioPrint i300 (VPi300) printer, which is depicted in Figure 1.

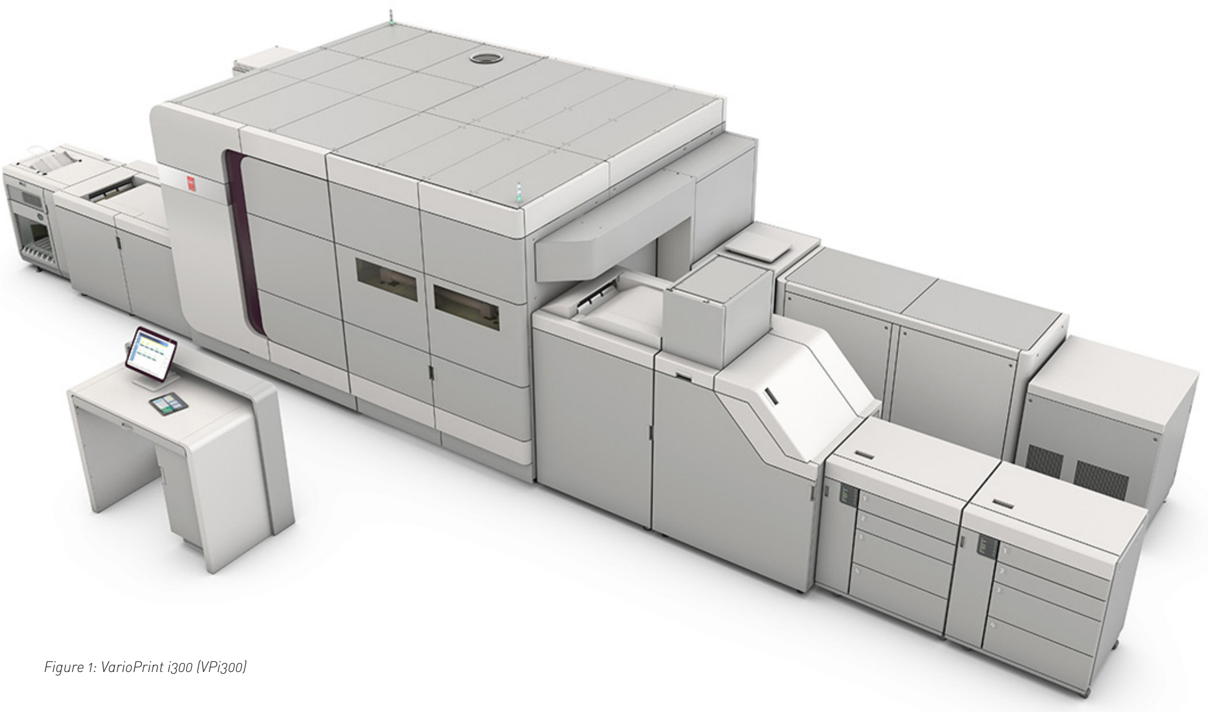
Figure 1: VarioPrint i300 (VPi300)

CURRENT SITUATION

Demand for service parts can be a result of either preventive, scheduled maintenance (PM) or from corrective, unscheduled maintenance (CM). However, currently, each demand is treated as being unscheduled and the inventory levels are determined accordingly. Although this is quite common in industry, the ADI that is available on PM demand is thus ignored, resulting in too high stock levels. For the VPi300, some parts are preventively maintained based on age thresholds, expressed in operating hours, days or clicks (the equivalent of a one-sided A4 print). PM needs to be performed on parts whose age has reached the fixed PM threshold, defined by R&D. These parts are currently stocked at every individual customer location. However, the aging rate of a part, which is the pace with which a part approaches the PM threshold, can be used to predict the demand for the spare part that will be used for the PM. Keeping track of the different age counters and predicting when a PM threshold will be reached generates ADI.

MODEL DEVELOPED

We propose to no longer keep stock at the customer location for the parts that generate ADI. For these parts a central stocking point close to a group of customer locations, called a Quick Response Stock (QRS), is used. We show how to use ADI contained in age-based and condition-based maintenance strategies in spare parts inventory control. We consider a single-location, multi-item inventory system. We develop the Preventive-Maintenance-based Advance Order (PMAO) policy, which is visualized in Figure 2. Under the PMAO policy, corrective, unscheduled demand is served from an inventory pool controlled by a base-stock policy, while preventive, scheduled demand is served by advance ordering the right quantity of parts using an advance order threshold. So, no inventory is kept on stock to fulfill PM demand. The advance order threshold is determined such that the parts required to fulfill the PM demand arrive on time in the QRS with a certain probability. Figure 2 shows for one system in the field the aging of a part, when PM replenishment is triggered, when

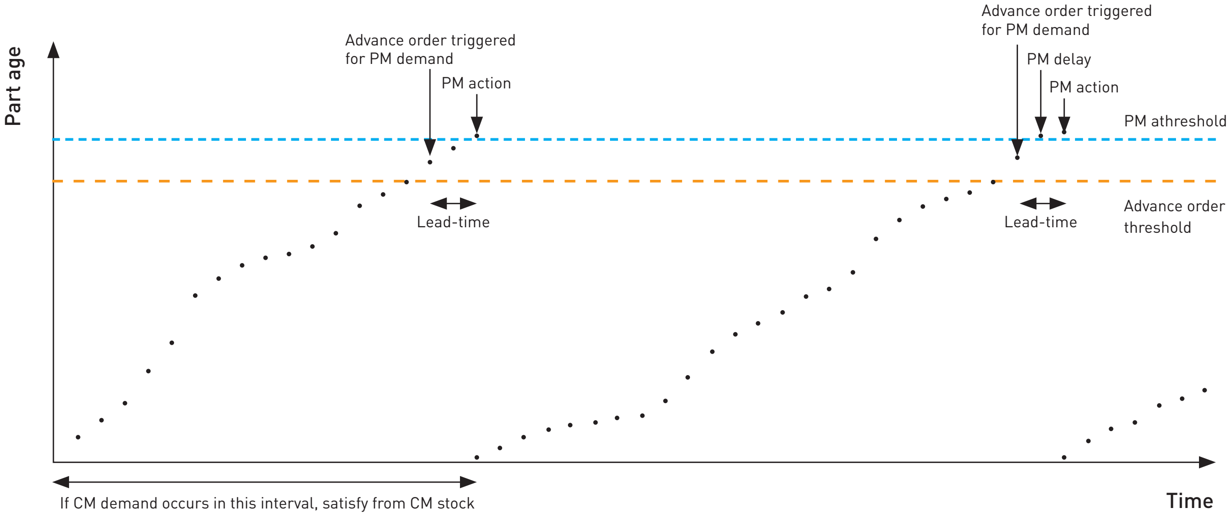

Figure 2: Part aging, allocation rules and ordering decisions PMAO policy

PM demand is generated and from which inventory pool a possible demand is satisfied. Multiple of these aging processes occur in parallel, since multiple machines, containing multiple parts, are served by one stock point.

We further propose an extension to this model, called the PMAO-extension policy, under which ordering of parts is done as under the PMAO policy, but the two demand streams are satisfied from a combined inventory pool: when a demand arises, no distinction is made between preventive or corrective demand. Lastly, we propose a simple base-stock policy applied to the QRS. So, we store parts centrally close to a group of customers, but do not make use of ADI.

CASE STUDY AND NUMERICAL EXPERIMENTS

To conduct a case study, we select a QRS in America serving six machines. We include 20 items and compare the PMAO, PMAO-extension, simple base-stock and current policies. We conclude that the PMAO-extension policy performs best with respect to inventory costs, which consist of operating and initial investment costs. However, we see that compared to the current policy, already huge cost savings can be gained when making use of a base-stock policy applied to the QRS: inventory costs can be reduced with a remarkable average of 80% per item for this six machines system. When using the PMAO-extension policy, inventory costs can be lowered by another 14%. In numerical experiments we vary selected input parameters to test how the PMAO-extension policy performs in future situations Océ will face. Compared to using the current policy, the total average costs when using the PMAO-extension policy are less sensitive to an increase of the number of machines in the system, which results in costs savings rapidly increasing with the number of machines when using the PMAO-extension policy instead of the current policy; the same holds for an increase in the lead-time. The savings depend on the number of machines served per QRS, which results in an average costs saving of 27% when our policy instead of the current policy is applied to America as a whole. The biggest increase in cost savings is gained when increasing the number of machines served from one to two (see Figure 3). As a consequence, because the installed base is increasing and Océ currently has a lot of QRSs serving only a single machine, the savings Océ will gain in the future increase.

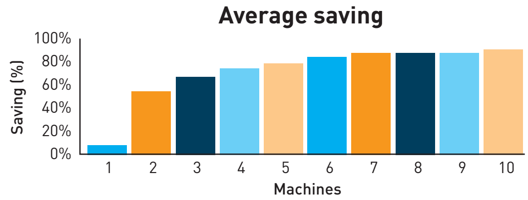

Figure 3: Percentage cost saving for PMAO-extension policy when increasing machines served

CONCLUSION

We have developed a new model to incorporate the ADI resulting from age-based or condition-based maintenance strategies in spare parts inventory control. Using the model we can show that it is recommended for Océ to make the connection between the maintenance planning and the spare parts inventory planning, in other words, to use the ADI contained in the maintenance planning. The savings for Océ when making this link are significant and will increase in the future when the installed base increases. A first step is pooling inventory in the QRS instead of keeping inventory at the customer location.

Topsector Logistiek

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