TKI DINALOG
Dutch Institute for Advanced Logistics

MACHINE FAILURE PREDICTION

CONDITION BASED MAINTENANCE AT OCÉ

Using sensor data to perform maintenance based on the condition of a printer.

Océ is a global leader in graphic arts, industrial printing and collaborative business services. One of Océ's products is the VarioPrint i300 (VPi300) printer, which is introduced to the market in 2015. Océ collects large amounts of sensor data from the VPi300 printer, which can be used for condition based maintenance (CBM) purposes. In this study, we develop CBM methods for diagnostics and prognostics, and apply the methods in three case studies. The cases are selected by focusing on error and warning occurrences of the VPi300 printer.

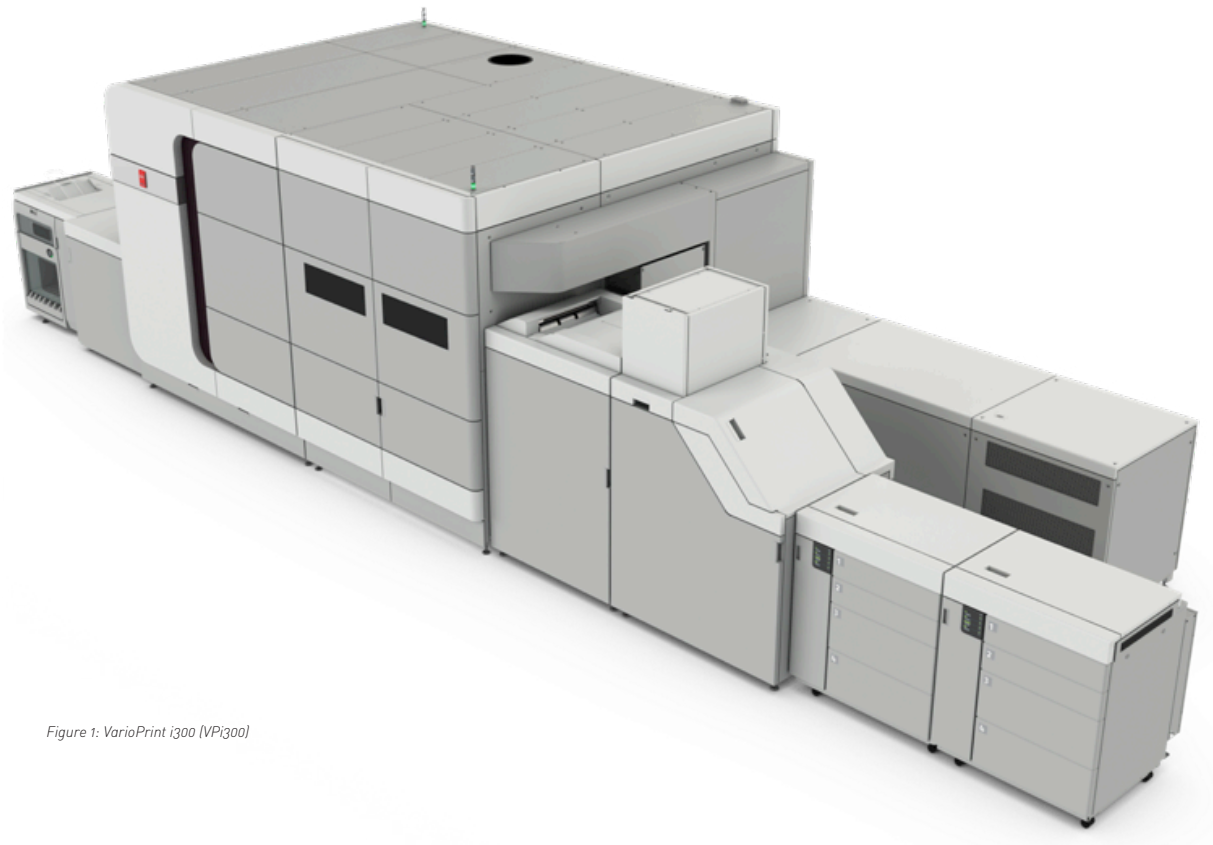

Figure 1: VarioPrint i300 (VPi300)

CASE SELECTION PROCEDURE

To select the three CBM cases, we apply a selection procedure to time-efficiently select variables that can be used to assess the condition of a subsystem. The selection procedure consists of two steps. First, we consider all occurrences of machine errors in a period and filter out a large amount of errors based on error type, frequency and some error specific features. This results in a small selection of error codes. Second, we identify the impact on machine downtime for each error code, and identify what variable triggers the error. We apply this method to select three variables with high impact. We perform data cleaning for these variables, to find three degradation signals that we use in our case studies. For one of these signals, degradation can only be observed hours or days before the first error occurs. Because of this short response time, we are only interested in defect diagnosis. For the other two signals, a longer response time is available. For these cases, we are interested in prognostics to optimize the timing of service visits.

DIAGNOSTICS

The diagnostics CBM method is used to diagnose impending failures of a subsystem of the printer. The goal of this CBM method is to diagnose defects in a subsystem of the printer early, such that maintenance can be performed before the printer fails. We do this by applying a control chart method, consisting of two steps. A measured quality characteristic is diagnosed to be out-of-bound if it exceeds some control limit. Subsequently, the subsystem is out-of-control if T successive measurements are out-of-bound. The control chart also considers the effect of an environmental factor. We apply the method to the maintenance box of the VPi300 printer. An increasing temperature measured in the maintenance box indicates a defect. Figure 2 shows an example of the control chart. Using the control chart, impending failures

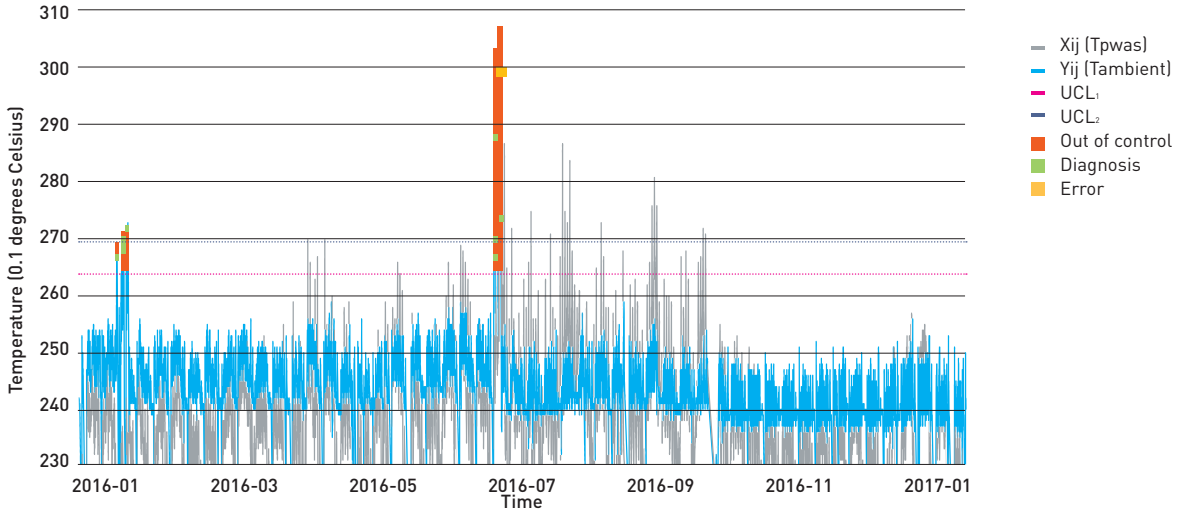

Figure 2: An example of the diagnostics control chart

can be diagnosed multiple days before actual failure occurs.

PROGNOSTICS

In case that the degradation of a subsystem can be monitored multiple months before actual failure of the subsystem occurs, a prognostics CBM method can be applied. For prognostics, we aim to characterize the degradation behavior of a subsystem of the printer, and set an optimal control limit to trigger maintenance actions. We do this by modeling degradation using a random coefficient model. Subsequently, we use the degradation model in a maintenance decision support model to set an optimal control limit that triggers maintenance. We apply the prognostics method in case studies. In one of the case studies, the condition of the sentry belt is assessed by monitoring the average amount of power (measured in PWM) that is needed to drive the sentry belt. An example of a degradation path and the corresponding degradation model is presented in Figure 3. By setting an optimal control limit that triggers maintenance actions, the prognostics CBM method can result in a cost reduction of over 25% compared to a corrective maintenance policy.

CONCLUSIONS

The results of both the diagnostics and prognostics CBM methods are promising. By applying the diagnostics method, impending failures can be diagnosed multiple days before actual failure happens. By applying the prognostics method, maintenance costs can be reduced by more than 25%. Therefore, we recommend Océ to test both CBM methods in pilot studies. To do so, it is important to clearly define the maintenance actions that should be triggered by the CBM method. Furthermore, we recommend Océ to investigate how the proposed CBM methods can be integrated with spare part logistics.

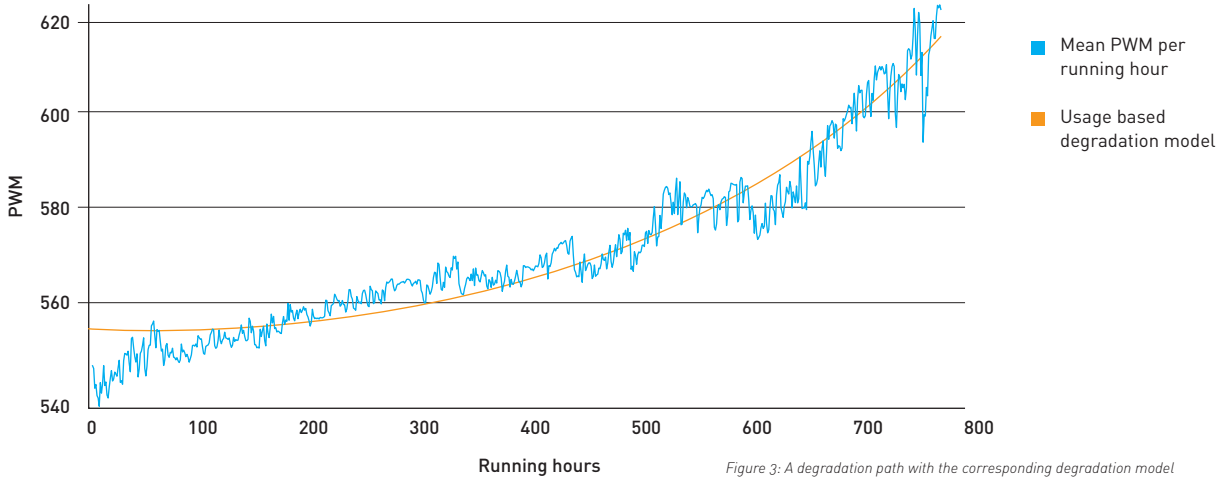

Figure 3: A degradation path with the corresponding degradation model

Topsector Logistiek

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