# KHS Product Division Packaging is continuously expanding its service portfolio and offers preventive maintenance

| Digital Enterprise | Industry 4.0 | Manufacturing | Preventive Maintenance | Virtual |


## Summary

Industry 4.0, the smart factory, the Internet of Things and cyber-physical systems are watchwords which – among other things – describe a constant rise in the level of digitization in the production process. However, in many cases it is not necessary to further fit machines with sensors and actuators as the machine is already capable of supplying data. All that is often lacking is a suitable connection and knowledge of how to usefully analyze and understand the available data. Together with its customer and partner Bavaria N.V. KHS GmbH has collected data from its machines and gained knowledge on maintenance in order that other customers can now also be assisted when optimizing their servicing procedures – right down to the provision of preventive maintenance.


## Introduction

On March 3 and 4, 2016, KHS GmbH held an in-house exhibition at its packaging machine production site in Kleve, Germany, under the motto of Innovation for U. Among the talks given by customers and partners the presentation held by Hans van Vijfeijken (global engineering and maintenance manager at Bavaria N.V.), entitled Packaging line of the future – preventive maintenance, awakened great interest. KHS GmbH has given Bavaria N.V. intensive support in the optimization of its maintenance processes for many years now. The results achieved thus far were outlined in the talk and the vision and objectives of the joint project explained.

The aim of the communal project is to replace the current time-based maintenance schedule with a program of preventive maintenance. Replacing a part at a fixed interval is then superseded by planned replacement close to the end of the part's life. To this end the part's condition must be monitored in order that its failure can be accurately predicted. All told, a preventive maintenance strategy makes maintenance easier to plan; service lives and thus production times can be lengthened and the number of unplanned downtimes is reduced. This in turn boosts the availability of the line which is reflected in the Overall Equipment Effectiveness (OEE). A cut in costs for maintenance can also be achieved. Bavaria N.V. has already been able to increase its OEE by 27 % and at the same time reduce its maintenance costs by € 16,000 per machine and year.

## Preventive maintenance

Choosing the right maintenance strategy has a major impact on the later cost of maintenance. KHS GmbH is already helping its customers with their maintenance programs by recommending a replacement interval for each spare and wear part. These replacement intervals have been empirically determined in countless field studies, already enabling customers to order the spare parts they require in good time. These spare and wear parts are stored at a central KHS warehouse so that here, too, clients can keep their own stocks to a minimum. However, even stipulating replacement intervals cannot ensure that a part is optimally exploited until the time comes for its exchange.

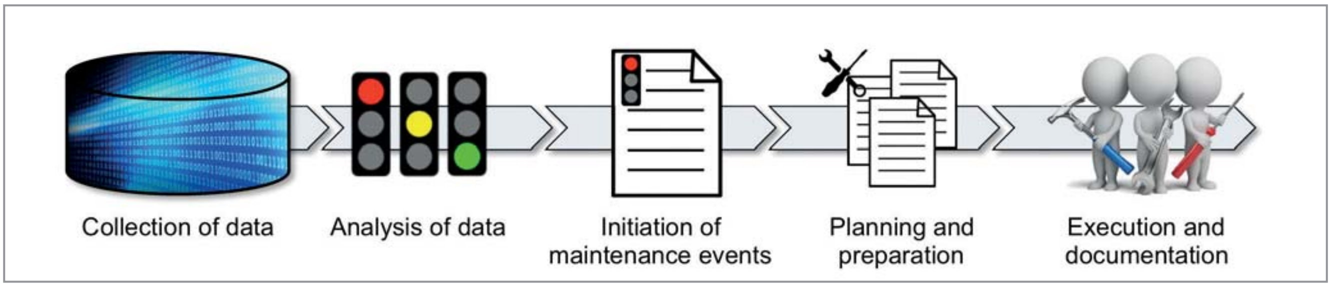


*Fig. 1: Concept of preventive maintenance* 

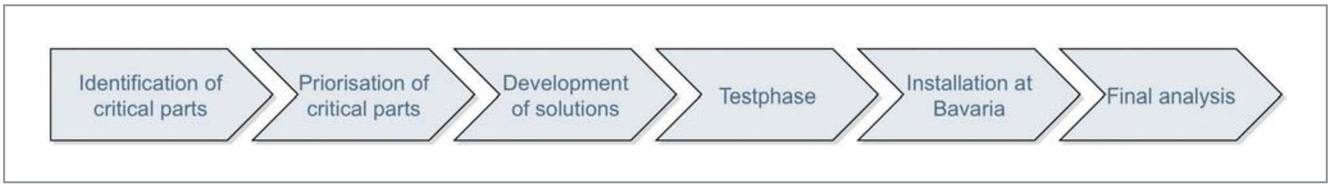


*Fig. 2: implementation of the project*

Preventive maintenance describes a strategy which enables a part to be used for as long as possible – while factoring in economic aspects and continuously monitoring the state of the part – before it is replaced shortly before the end of its life. Maintenance activities are planned so as to enable as many measures as possible to be combined to prevent long downtimes. In this process the wear-and-tear contingency must be known and information must be available on the replacement of the part (fig. 1).

An increasing level of digitization, also in production, means that it is becoming much easier to access data generated during the production process and required for monitoring the condition of parts and components. Packaging machines in particular yield a multitude of machine data which at the moment is primarily recorded for reporting purposes only. However, providing the right methods of evaluation are applied, there is considerably more data available which sometimes contains a lot of information, such as on the degree of wear of a part.

Collecting this data is merely the first step in the process (cf. Figure 1). It is the analysis thereof which turns this data into information which can be used during maintenance, such as information on a pending failure of components. At the same time, however, the analysis process must also monitor the product in real time – where possible – and indicate a pending failure using mechanisms which are easy for everyone to understand (a traffic light system, for example).

By using suitable methods of evaluation a failure can be predicted well in advance, allowing maintenance events to be scheduled and planned in good time. Parts can also be procured and personnel planned in a timely manner, permitting vacation periods to be accounted for, for example.

Each worker is specifically provided with the spare parts and tools needed for each maintenance event, eliminating long searches for parts or equipment. The worker can therefore perform maintenance measures faster than in the past and afterwards precisely document which work has been carried out.

**The preventive maintenance project by KHS and Bavaria N.V.**

The preventive maintenance project has taken an important step towards monitoring the condition of the machine and predicting faults. KHS GmbH and Bavaria N.V. implemented the joint project in several different stages (cf. Figure 2). An analysis was first made to identify critical parts and components. These parts and components were then assessed to determine an order in which solutions were to be found. These solutions were tested at the Kleve plant on a KHS Innopack Kisters machine and, once these had proved successful, directly installed at Bavaria N.V. Algorithms are currently being developed to evaluate data more efficiently than has been the case to date (fig. 2).

The production process is very well documented at Bavaria N.V., meaning a wide range of data was already available at the start of the project. For instance, each downtime, maintenance measure and – if known – the reason thereof are recorded. Even supposedly minor downtimes, caused by a downed product, for example, are noted. The machines supplied by KHS GmbH are of course already providing assistance here, as each fault detected by the machine is stored in the Human Machine Interface (HMI) where it can be clearly identified by its error code and read out. The data this generates was evaluated and a historical profile of the examined packaging machines drawn up. This profile provided information on recurring errors and the remedial action taken. It was thus possible to see exactly which faults had occurred when and how often, what impact these had had and which actions had helped to remedy the fault.

The faults which either occurred particularly often or led to long, unplanned downtimes were first selected using a method based on Failure Mode and Effects Analysis (FMEA) in order to work out suitable solution concepts. Part of this solution concept was always to detect the fault as early as possible. It transpired that many problems could already be determined from the data generated in the machine. Sensors only had to be retrofitted to cover a few points.

The ensuing steps taken to develop a suitable solution concept and ultimately a finished solution shall now be elucidated in the following two select examples. The first example clearly demonstrates how existing data can be used for evaluation during preventive, condition-based maintenance. The second example illustrates how the use of just one sensor can give customers a number of benefits.

**Example 1: monitoring servomotors and connected components**

The packaging machines from KHS GmbH can be optimally adapted to suit the individual requirements of the customer. To this end the modular machines are individually assembled for each and every customer. Controlled servomotors are used in the machines at several points in the process.

These servomotors are controlled by means of a programmable logic controller (PLC). Commands are sent to the servomotors at millisecond intervals and at the same time the current position is recorded. The controller thus 'knows' at all times which position a motor currently has and how to proceed so as to achieve the set profile. Data needed for control or computed from the controller, such as flows, torques, positions and temperatures, etc., is already available but used exclusively for control purposes.

It is possible to read out the aforementioned data. This, however, is on the condition that 1) there is sufficient computing power available so that the production process is not disrupted and 2) there is enough storage capacity to save the amount of data generated. Cloud systems and big data provide possible solutions here; these can be tailored for each individual client. Fast data access – necessary for evaluation – can thus be ensured, also after a readout.

The data is evaluated immediately with a number of objectives. Firstly, the amount of wear in the drives and their load is detected. Applying descriptive statistics methods the system can then ascertain whether or when a drive has to be replaced. The same applies to the monitoring of any installed couplings or gears. Their state is recorded by monitoring 'jumps' and 'knocks' in the torque graph (fig. 3).

Monitoring the torque also provides information on the masses transported which in turn is used to detect the wear on conveyor belts, for example. Using artificial intelligence processes this information is compared to the messages contained in the HMI. In this way operators can predict when belts have to be replaced.

Monitoring just a few signals therefore allows several components to be monitored. Servomotors, couplings, gears and belts are just a few of the components which can be continuously monitored by evaluating control data.

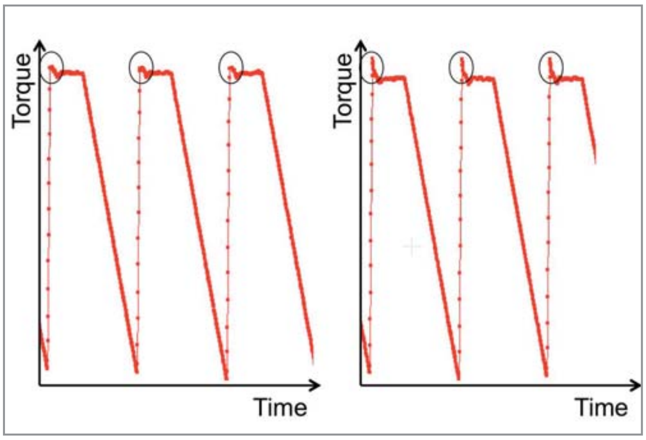


*Fig. 3: left: torque graph of a new, controlled servomotor; right: torque jumps caused by coupling wear*

**Example 2: detecting wear-related changes in length of roller chains**

By the nature of their design the roller chains often used on packaging machines – and also in other fields of industry – are subject to wear. This wear is manifested in a change in the chain length. This effect is a well-known fact and can lead to problems in many areas. When the length of a chain alters, synchronization is no longer ensured at the transition points and products can no longer be transferred, resulting in disruptions in production.

To compensate for changes in chain length the timing for transition can already be exactly configured in the HMI. By tracking the new configuration an overall change in length could be determined which would, however, be very inaccurate. It is nevertheless necessary to discern the overall change in chain length as this is a measure of the amount of wear. If the change in length exceeds a value of 3 % as a general rule (values which deviate slightly from this are mentioned in specialist literature and by manufacturers), it is also assumed that the actuating gear wheels are worn.

Particularly worn chains also tend to skip a cog on the gear wheel. If this happens, synchronization is no longer ensured and there are also problems in production. Other effects, such as soiling, can also cause chains to jump. The consequences of this are usually serious, as the chain first has to be put back into its correct position – yet the correct position is not known.

A system has been developed which precisely detects the position and length of the chain. Jumps can now be directly recognized and stopped before the process is disrupted. Resetting the chain is only necessary with paired chains. Otherwise, the zero point can be reconfigured and production immediately resumed. Synchronization is also ensured by a correction value being directly entered into the HMI. The operator can immediately adopt this (fig. 4).

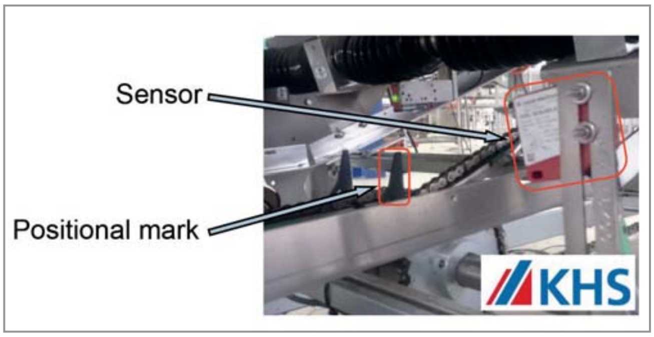


*Fig. 4: Sensor for detecting changes in length of roller chains*

Another positive effect is that replacement of the chain can be precisely calculated. Using learning algorithms the behavior of the chain is extremely accurately predicted, enabling chain replacement to be planned in the long term.

**Conclusion**

The way to preventive maintenance lies in the evaluation of available data. Recording and storing this data no longer poses a great problem in our day and age. Thanks to cloud computing, big data and the many endeavors being undertaken in the name of Industry 4.0 the general conditions are a given.

The difficulty instead lies in the evaluation of the collected data. Years of company experience are called for here. Through the strategic partnership of KHS GmbH and Bavaria N.V. as the operator of several systems, KHS GmbH has the necessary application expertise to be able to usefully analyze machine data.

The specialists from KHS GmbH apply various methods taken from the field of descriptive statistics and artificial intelligence to permit appropriate early detection for all potential faults. Only when several methods are combined can the failure of a component also be predicted with any accuracy. This gives the customer a number of benefits. Spare parts can be ordered just in time, thus preventing large stocks of spares. Maintenance can be planned efficiently and in the long term. Unplanned downtimes are avoided through continuous, automated monitoring processes. System availability is ultimately increased and at the same time costs for maintenance are reduced.

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