MOBILITY & PRODUCTION

Fields of Expertise TU Graz

Source: istockphoto.com/fotolia.com

Helmut Eichlseder,
Mobility & Production
Source: Lunghammer – TU Graz

Various research initiatives and projects of the Field of Expertise cover the technology change in Mobility and Production. This is also reflected in the courses offered at Graz University of Technology. A representative example is the redesign of the specific master's degree programme in Engine and Propulsion Systems at the Faculty of Mechanical Engineering and Economic Sciences, which now covers all drive technologies based on battery-electric and hybrid systems, hydrogen and internal combustion engines.

A research activity that also addresses the topic of mobility on a broad basis is the Sustainable Passenger and Freight Mobility initiative. Launched in January 2020 at the Faculty of Mechanical Engineering and Economic Sciences, it thematically bundles nine PhDs with the aim of developing new technologies and processes to increase efficiency and reduce greenhouse gas emissions in the transport sector.

The research activities concerning production can be exemplified by the following article by Rudolf Pichler. Another encouraging example establishing the production focus is the funding commitment for the Qualification Network tendered by the FFG, which was awarded to the Institute of Production Engineering as consortium leader. 125 trainees from 22 companies (11 of which are SMEs) will be trained over two years by TU Graz, FH CAMPUS 02 and Joanneum Research Robotics on the core topics of Smart Factory and Cyber Security. The training will be carried out together with LLL (Life Long Learning).

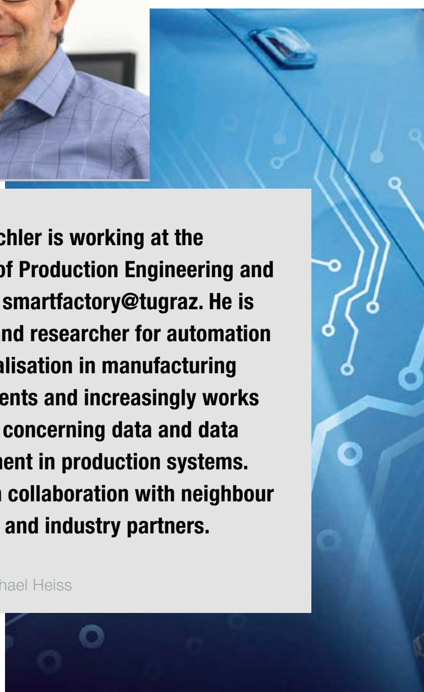
One upcoming event is a highlight for all Fields of Expertise: researchers from all five Fields of Expertise will show how they help to shape our future at the new annual science day of TU Graz TU Graz – Science for Future on 29 September 2021.

Another event was a highlight specifically for our FoE: the virtual opening of the smartfactory@tugraz in April with over 230 invited guests. Industry and research partners are invited to participate in a wide range of projects related to digitalization in production.

Rudolf Pichler

High Frequency Data Capturing for Process Innovation at Machine Tools

The systematic capture of data is the jump off base for developing knowledge about any process. Doing investigations during fast running processes, for instance during the chipping process of a tool machine, there is a need to acquire data at a very high rate. Special hardware and software are required in order to make this special kind of data capture work. Such a set up – in this case within or just before the breakage of a drill – and the outcomes are shown in the following.



Rudolf Pichler is working at the Institute of Production Engineering and leads the smartfactory@tugraz. He is lecturer and researcher for automation and digitalisation in manufacturing environments and increasingly works on topics concerning data and data management in production systems. This all in collaboration with neighbour institutes and industry partners.

Source: Michael Heiss

INITIAL SITUATION

Understanding a process has always been based on having knowledge about its corresponding process data. In the same way it is agreed that working with a maximum of data provides an even higher significance regarding deduced statements in the investigated processes. This approach leads to the apparent fact that the evidence or the draw of data is a trivial and routine operation because data simply is available or easy to get. But looking at investigations which take place during fast running pro-

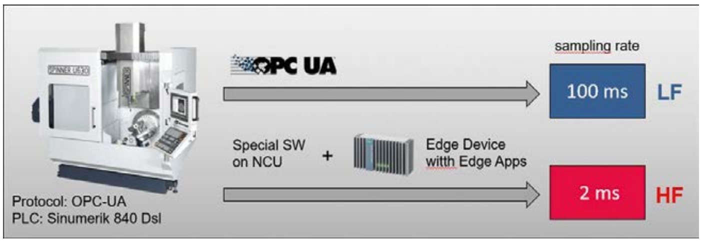


Figure 1: The HF-data capture provides a 50 times higher sampling rate than working with OPC-UA (author's own representation).
Source: TU Graz / Pichler

cesses presents a new challenge. In such cases the methods for capturing the relevant data on certain values of the process in question must be able to collect sufficient data within only a very short period.

This article is dedicated to the detailed procedures of drilling and leading up to the breakage of the drill. The interesting phase just before the effective breakage does not last longer than a few fractions of a second. Even if the studies were carried out on a machine with a modern OPC-UA interface, the achievable capture rate would not be higher than 10 data points per second. And such a data panel would turn out to be too weak for acquiring satisfying knowledge about breakage mechanisms.

SET-UP FOR CARRYING OUT THE HIGH FREQUENCY DATA CAPTURE

The following introduces an innovative set-up for facilitating an even higher sampling rate of data points than only 10 per second, thus designated as low frequency (LF) data capture. By the use of special software and a so-called edge device, the high frequency (HF) data capture with sampling rates 50 times higher can be realized (see Figure 1).

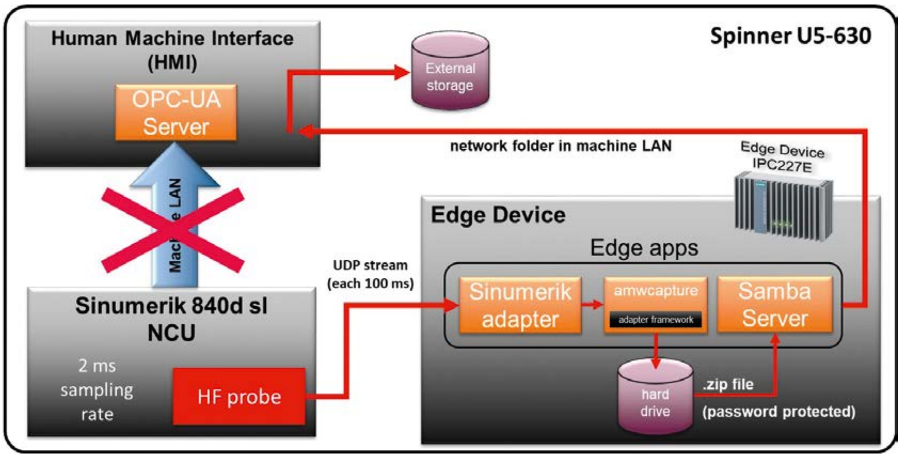
The new set-up (see Figure 2) requires an additional and external computing unit which is finally not more than an industrial PC (IPC), in this case of the type Siemens IPC227E. Since this IPC can and will also be used for edge computing activities, it is also called the edge device. For the demonstrated application this IPC also carries a Sinumerik adapter which in general is the relevant connection between the NCU of the machine tool and all Sinumerik Edge applications running on the edge device. It must be mentioned that such a Sinumerik adapter only supports connection to a single NCU but can receive up to a maximum of 50 active parameter requests in parallel. When working on this architecture, the usual data transfer to the HMI is disabled.

To capture HF signals an HF probe as initial sensor inside the SINUMERIK 840d sl NCU executes this procedure at a sampling rate of 2 ms. Hereafter the proprietary User Datagram Protocol (UDP) does the upload stream to the Sinumerik adapter but at a reduced sampling rate of 100 ms. During this, the edge app "amw/capture" (see workpiece/capture) stores the data on a hard drive. From there the data is prepared to finally go back to the HMI via a universally accessible Samba Server. The HMI finally offers various options to forward the captured HF data for external use or storage again.

EXECUTION OF THE HF-DATA CAPTURE AND INTERPRETATION OF ITS DATA

The technical set-up described above was executed on the CNC-machine tool Spinner 630-UA in the smartfactory@tugraz. The application design for the HF data capture was the drilling operation of drill bits with a diameter of 2.8 mm which were forced until they broke in order to find the mechanisms just before and at the point of breakage. The current consumption of the main spindle SP1 and the current consumption of the spindle feed in z-Axis Z1 were defined as relevant values to be captured. Figure 3 shows the best fit representation of 14 breakage recordings. The graphs and the data points of the HF (red line) and the LF (blue line) data capture show first the current consumption of the main spindle (left side) and secondly the current consumption for the spindle feed (right side). >

Figure 2: Scheme of the set-up for working with HF data capture (own representation following [1])
Source: TU Graz / Pichler



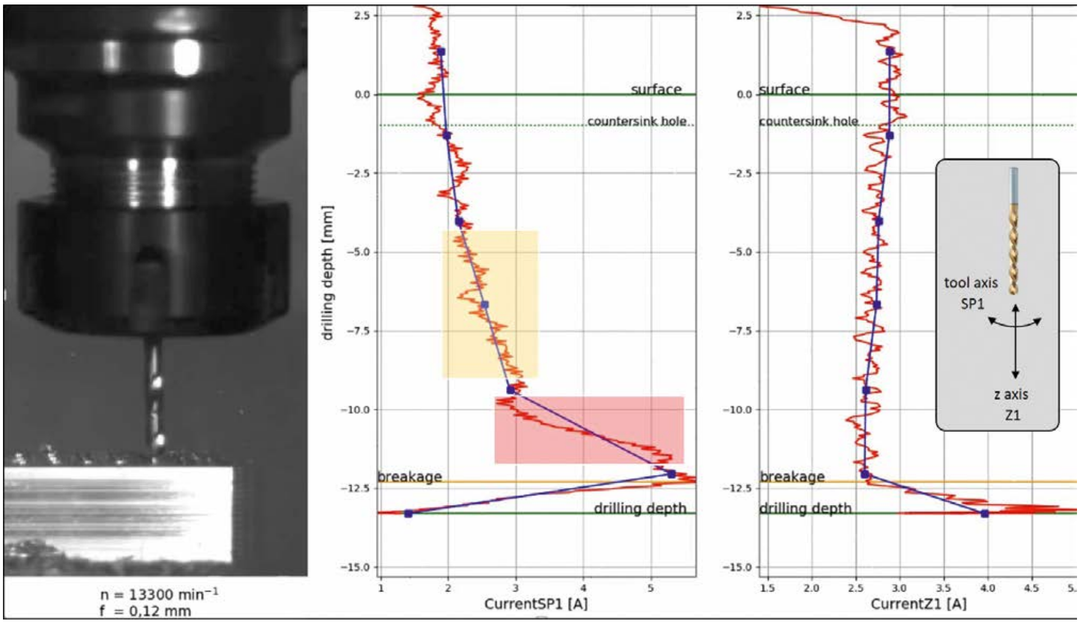


Figure 3: HF and LF data lines for 2 values of a drilling process
Source: Butzerin [2])

In general, the courses of the graphs are not astonishing. Looking at the left graph of Figure 3 in the phase where the data area is highlighted in yellow, a soft incline of the current consumption can be seen. This is because the drill gets a so-called built-up edge. In this phase little material of the workpiece is more or less welded onto the cutting edge of the drill bit. This weakens the cutting edge, leads to higher resistance of the drive of the main spindle and ends up in a higher energy consumption. The growing effects of the built-up edge and the intentionally applied enforcement of the drilling process in order to make the drill bit break can be seen in the ongoing increase of the current consumption (highlighted red rectangular). After having reached the maximum and effective breakage of the drill, the current consumption breaks down immediately because of the no longer existing mechanical resistance of the spindle drive.

What can also clearly be seen on these graphs is the 50 times higher number of data points at the HF data line (red) in comparison with the LF data line (blue). Especially for such a fast running process the higher density in data provision is decisive for sound deductions and developing scientific statements. It becomes quite evident that the delivery of important information via the LF-capturing mode would not be appropriate or early enough for the release of any mitigation in order to avoid the breakage of the drill.

DISSIMINATION AND ONGOING RESEARCH

Apart from the elaborated insights as to how the breakage of a drill bit develops, if and how such an incident can be avoided is even more interesting. The critical stage of the process lies in the phase when entering the yellow phase in Figure 3. If a limit is set to the special value "current consumption of the main spindle" and a real trend is visible due to a high density of data points, then countermeasures could be triggered such as the reduction of the feed or the drive. The real advantage is that according to so many data points available from the HF capture the system can react in time. Up until now countermeasures were triggered only by the next decisive LF data point, which in many stages would be already too late to react.

For processes where the correlation between certain values and their data points cannot be interpreted that clearly such as in the given example with the drill bit, the method of working with learning algorithms can be used. The value-data pattern of processes that are regular and work well are recorded – in best case at HF-level – and set as a standard. The later control of repeated processes steadily checks the conformity of data points with the reference pattern. If there is any defined deviation, an alert will follow and actions for mitigation can take place. The programs for this "anomaly detection" are also installed in the already introduced edge device.

REFERENCE LIST:

[1] Trabesinger, S., Butzerin, A., Schall, D., Pichler, R., *Analysis of High Frequency Data of a Machine Tool via Edge Computing*, in: Procedia Manufacturing 45 (2020) 343–348.

[2] Butzerin, A., *Analysis of High-Frequency Machine Data via Edge Computing*, Master Thesis, Graz University of Technology, Graz 2019.

[3] OPC Foundation, *OPC 10000-3 Unified Architecture Part 1 Overview and Concepts Publish-Subscribe*, https://reference.opcfoundation.org/v104/Core/docs/part1/6.5/, retrieved at 27/03/2021.

[4] Siemens, *Industrial Edge*, https://new.siemens.com/global/en/products/automation/topic-areas/industrial-edge.html, retrieved at 05/03/2021.