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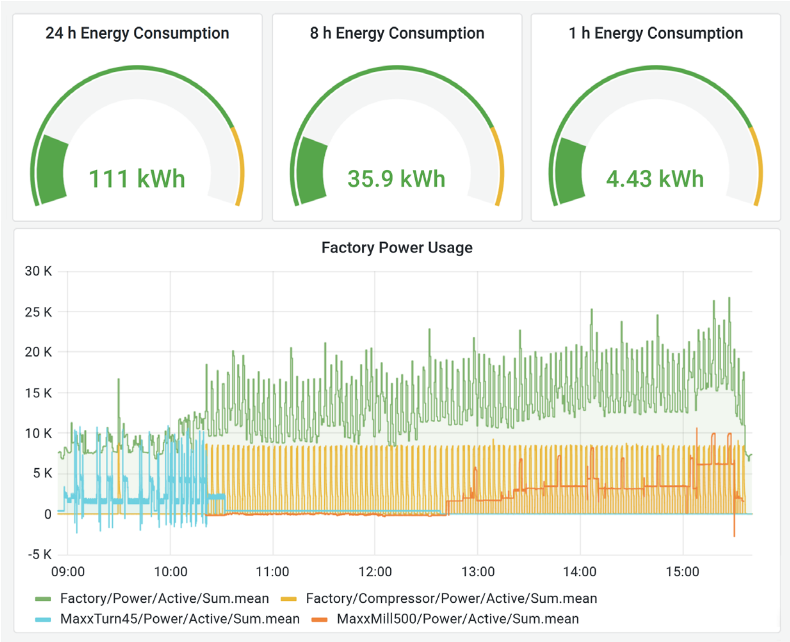
Energy efficiency in machining

Feature-based energy data acquisition and optimization in the metal-cutting production

At present, the energy factor is becoming increasingly important in the manufacturing industry – you know the keywords: energy shortage, climate change, energy transition. Against this background, the EU Efficiency Directive obliges energy suppliers and manufacturing companies to demonstrate that they have realized energy savings through efficiency measures on an annual basis.

The framework for the digital product passport was proposed by the European Commission in 2022, in connection with the Sustainable Products Regulation. This means that in the future, it will also be necessary to record and assign energy data from components for the calculation of CO_2 footprints. The further detailed consideration of data at the level of the geometric form elements of components - so-called "features" - offers enormous potential for forecasting and downstream analysis of energy consumption of manufacturing processes as well as for calculating the CO_2 footprint.



Energy consumption measurements form the basis of efficiency improvement and the resulting products' CO_2-footprints

Objectives

Research at the Institute of Production Engineering and Photonic Technologies (IFT) at the TU Wien is focused on flexible linking and feedback of energy and process data. The data is linked from production systems to process parameters from computer-aided work preparation at the manufacturing system level, via the machine level, down to the product and feature level. This makes it possible to determine key figures (such as the share of electrical power in the CO2 footprint) and to visualize and subsequently optimize the profile of electrical power over the processing path as well as the local energy input. Feature-based energy data collection provides the basis for predicting expected energy consumption per machined feature. AI approaches can be used to create comparably similar form elements on different components.

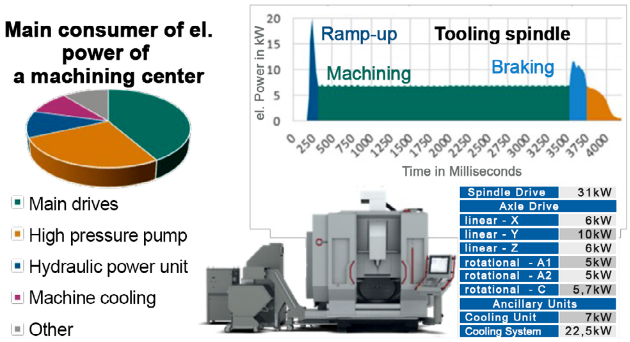
Approach

In order to model a basis for measures that increase energy efficiency, transparency in energy consumption, flows and energy measurements is essential. Energy monitoring is used to centrally record, visualize, process and store measurement data - such as electrical power, pressures, temperatures or volume flows of media.

The typical, classical monitoring approach is done at the company level, and determines the energy consumption of the entire plant as well as specific areas. If there is insufficient knowledge about the main energy consumers and their operating behavior, it makes sense to identify them by means of short-term measurements with mobile measuring devices, and to determine the potential savings.

The second monitoring approach is that at the plant, machine and process level. By interpreting high-resolution energy measurement data or operating data from machine controls, targeted measures for monitoring and optimizing processes can be derived. In practice, it has been shown that energy efficiency and productivity at the process level usually go hand in hand.

The third and more comprehensive approach captures the machine data of an NC machining process at the feature level and feeds it back into work preparation. This closes an important data and information loop (closed-loop manufacturing), which facilitates detailed



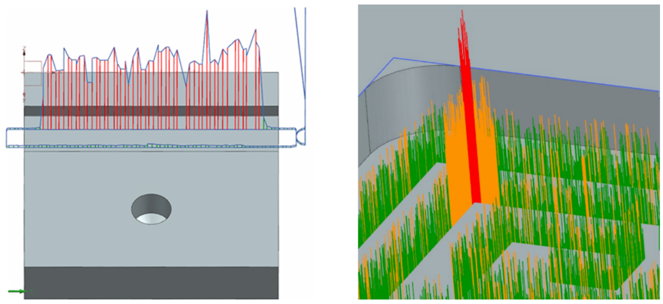
Example for energy data at the machine level

visualization and manual optimization of the individual manufacturing processes. It's also a prerequisite for viewing products based on their individual features, automatically comparing and optimizing them with the machining parameters and associated process data already collected within the company.

A machine-specific extension in the postprocessor within the CAM system automatically creates identifiable marks in the NC program, which are recorded in time series process data during machining, and which enable subsequent assignment to the machining features.

Results

In the Pilot Factory of the TU Wien as well as in the TEC-Lab of IFT at the TU Wien, a comprehensive energy monitoring system was implemented in which sensor data and operating data from machines are visualized and interpreted. The system has already been tested and implemented in several industrial production facilities. Production processes have been optimized, productivity increased, energy peaks cut, and energy consumption significantly reduced.



Visualization of power uptake (left) and energy input (right) via the machining path for individual parts at the feature level

A closed-loop manufacturing approach to data acquisition and process optimization has already been successfully implemented in several projects at both the product and feature level.

Your Advantages

Depending on the application, a temporary or longer-term detailed energy analysis in your company brings the following advantages:

- "Quick wins" by identifying and optimizing the largest base load and peak consumers
- Real-time evaluation of the energy efficiency of manufacturing processes, by integrating energy-related sensor data and machine control data - standalone or integrated into the product life cycle
- For the first time, linking of comprehensive and detailed energy data with component-related form elements (features)
- Optimization of production planning and adjustment of energy demand to supply - enabled by forecasting energy consumption for alternative production scenarios
- "Condition Monitoring" of machines, to draw conclusions about product quality and to prevent machine defects.
- Determination of individual CO_2 footprints at both the product and feature level

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