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Smart 5G Machine Vice

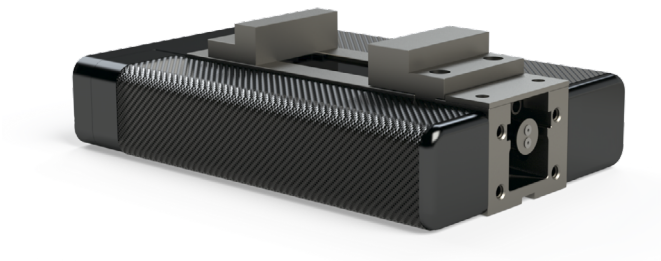
Automatically adapts clamping forces to real-time process conditions

Machine vices have long been recognized as the preferred means to clamp workpieces during machine manufacture and in machining centers. Modern tooling machines are highly automated, however they are not capable of sensing the current state of a workpiece during its production. New developments in autonomous production and “Industry 4.0” make it necessary to aim for as much autonomy and self-optimization in production as possible. Autonomy and self-optimization are as important for small lot sizes as they are for mass production. Therefore, it is necessary to implement novel approaches.

In the future, physical cables for communication purposes should be replaced with 5G communication capable of real-time messaging, whenever possible. In this way, errors can be avoided, equipment maintenance can be simplified, and external disturbances can be eliminated. If machine components are able to record data concerning both the current state of the workpiece as it is produced, as well as the operating parameters of production machines, the resulting data can be fed back into a self-optimizing manufacturing control loop. This automated feedback loop uses real-time data and supports the goals of energy efficiency and cost reduction.

Objective

Dr. Friedrich Bleicher and his employees at the Institute for Manufacturing and Photonic Technologies at the TU Wien had the goal to develop an intelligent, sensor-based clamping system that could fit the demand for further acceleration of speed and flexibility in machine production processes. They aimed to combine automated clamping with an intelligent clamping force control loop. At the same time, they wanted data recorded during operation of the machine to be fed back into the machine controller. They wanted the data recorded to be sent over a fast 5G wireless network to a ML-unit and from there be fed into the machine controller, enabling continuous optimization of current operating parameters.



Smart 5G machine vice with integrated clamping force feedback control for autonomous production – developed in cooperation with ALLMATIC Jakob Spannsysteme GmbH (right: connecting threads for robot coupling)

Solution

This forward-looking concept was made a reality using a tried-and-true machine vice from ALLMATIC Jakob Spannsysteme GmbH as its basis. An integrated force sensor makes it possible to record the clamping force necessary from moment to moment. The required clamping force is supplied via an electromechanical powertrain with direct current motor (24V) and transmission which was specially developed for this application. In this way, the required clamping force can be applied and regulated for each production timepoint. Additionally, the system is equipped with a 3-axis accelerometer sensor and can optionally be equipped with a measurement microphone. These two features allow vibrational phenomena to be recorded in detail, analyzed and if necessary, the associated parameters may be corrected while production takes place.

The system is supplied with electricity through integrated batteries (operation up to 24h), which are recharged inductively (contactlessly). Communication with the other active components of the production line or cell is accomplished via real-time capable 5G connectivity, which supports closed-loop control regardless of the manufacturer.

Data recorded during operation is streamed to a high-performance network server and analyzed using

algorithms and machine learning (ML) models. Optimization parameters are then sent back in real-time to the production center, which can then optimally react to current process requirements. The system uses and constantly and automatically trains its ML-models in real-time.

Results

The final result is the Autoclamp 5G, a universally applicable clamping system. Real-time applications of the system are made possible via cutting-edge 5G-mobile technology. Its industry-standard zero-point clamping system and robot coupling allow it to be positioned and operated by robot systems in a precise, repeatable fashion. The smart 5G machine vice makes use of the many capabilities of a 5G standalone campus network – such a network was implemented for the first time in Europe at the TU Wien.

Broad-based testing of the system in production is being carried out in cooperation with selected industry partners. The use of the system immediately results in a reduction of downtimes and production waste. It also leads to the opening of many possibilities for process optimization and predictive maintenance. All this is possible both during the semi-automated contract production of small lot sizes as well as in large, highly automated, flexible production lines with 3-shift operations.

autonomous material handling of the 5G-machine vice
(at time of photo still a prototype) in a production facility

Your Benefits

- Globally, the first autonomous machine vice with 5G integration (eMBB, mMTC, uRLLC)
- Analysis and implementation of recorded operational data via Machine Learning: for real-time process control
- guarantees maximum cutting speed and feed rate at all times
- additional sensors for process automation of operating parameters such as noise level, vibrations, temperatures and 5G indoor positioning may be integrated using the machine vice's 5G interface
- reduces sources of error and production waste as well as downtime, and guarantees secure operations during automatic recording and control of clamping forces
- also suitable for small lots and one-off production pieces which may require the highest standards of process documentation (i.e. aerospace industry)
- supports both optimization of manufacturing processes and predictive maintenance
- battery operated and autonomous for 3-shift operation, with contactless recharging ability
- compatible with the zero-point clamping system of all manufacturers and equipped with a robot coupling for autonomous material handling
- robust, durable and inexpensive

The TU Wien owns the first production facility in Europe to be equipped with a comprehensive, private 5G standalone campus-wide service network. Both our infrastructure and the positive experience we have gathered producing the very first smart 5G machine components for "Industry 4.0" can be made available to industry partners for the development and testing of their own smart 5G components, as part of cooperative projects.

Notes

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