Dynamic performance testing of cutting tools

Real-time vibration monitoring and analysis system

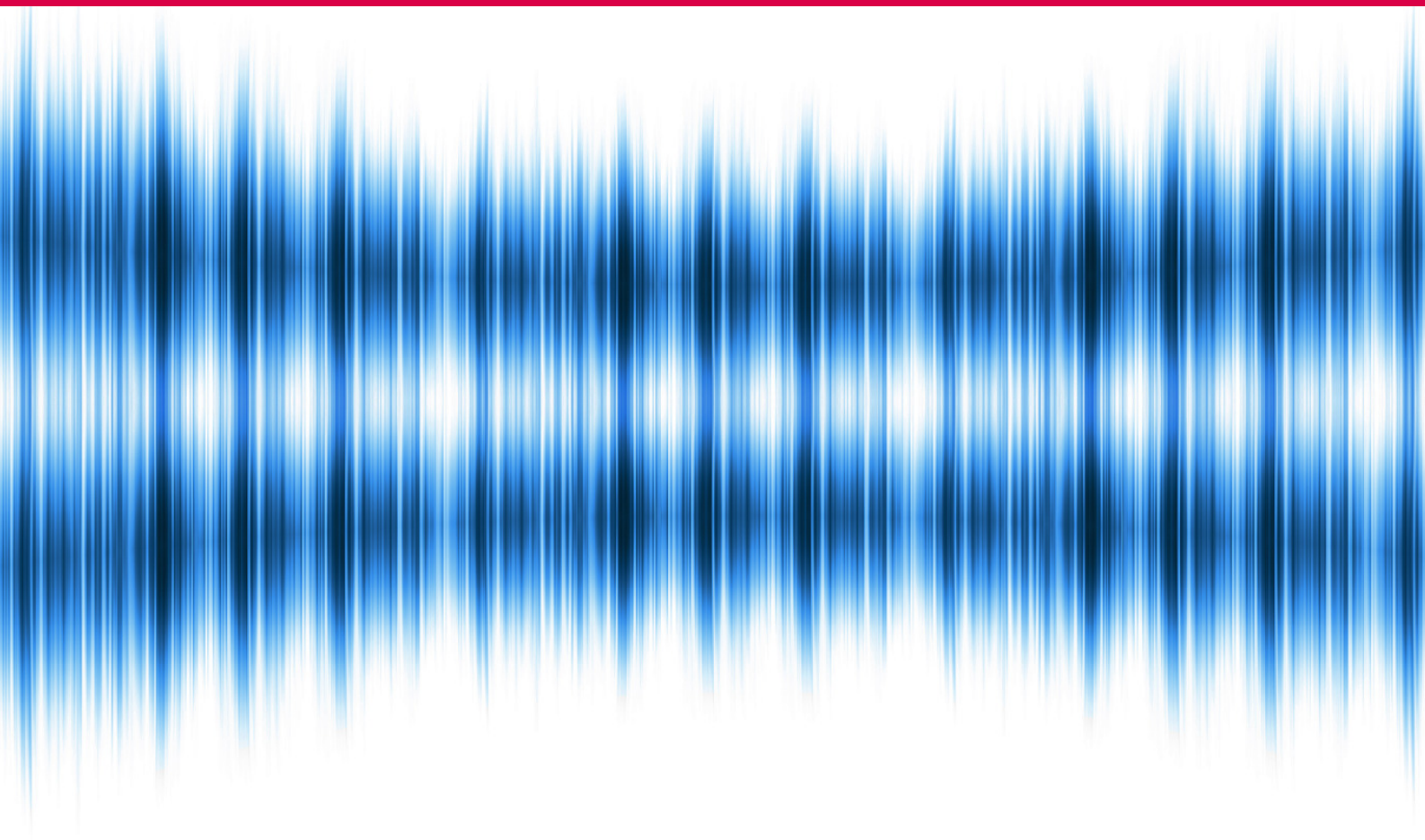

Fig. 1: Soundwave ©iStock/hudiemm

The abrasion of cutters on CNC machine tools will directly affect the quality of workpieces as wear progresses. This application note discusses how to use the “imc real-time vibration monitoring system” for real-time inspection and analysis of dynamic cutter performance and make evaluations and predictions to improve and optimize the cutter.

Carbide cutter – an important part of CNC machine tools

CNC (= Computer Numerical Controlled) machines are an important basis for manufacturing. The cutter performance of CNC machine tools directly affects the workpiece machining quality and surface precision. With the increasing wear of cutters, their dynamic properties are constantly changing and effective evaluation methods are needed to dynamically monitor, analyze and evaluate alloy cutters in order to improve and optimize the cutter.

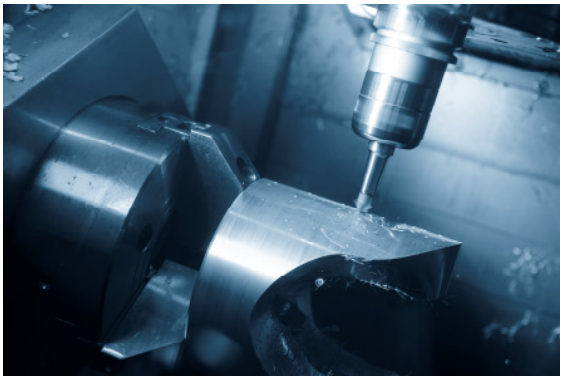

Fig. 2: CNC Cutter ©istock/Phuchit

Monitoring the dynamic cutter performance

Cutter wear and breakage can be monitored by applying an accelerometer and a microphone as sensors. While cutter edge rubs against workpiece during the cutting process it generates different amplitudes and vibrations at different frequencies. These are closely related to the state of the cutter. The sensor is usually attached to the surface of the tool and is easy to install. This method can be applied to different machine tools and tool installation methods.

The evaluation method includes the following variables:

- Machine RPM
- Feed speed
- Back engagement

Noise and vibration analysis

To measure the noise and acceleration signals of the CNC cutter, and to setup an NVH analysis easily, the imc CRONOS*flex*-400 measurement device was used with an additional CRFX/ICPU2-8 module. To evaluate all of the test results and to assess them according to internal and external standards, imc FAMOS signal analysis software is ideal. Using this software, current measurements can be subsequently analyzed, including comparisons with internal data files and other external references.

With the imc STUDIO software, several graphical user interfaces were built to enable employees to perform analyses quickly and easily.

System Overview

imc measurement device	Qty.
imc CRONOS*flex* base unit CRFX-400	1
Module	
CRFX/ICPU2-8 module Broadband measurement amplifier	1
Three-axis accelerometer and a microphone	1
imc Software	
imc Online FAMOS Real-time data analysis tool for imc CRONOS	
imc FAMOS Data analysis framework	
imc STUDIO Pro Integrated software for the entire measurement process	

Fig. 3: imc CRONOS*flex*-400 ©imc

imc CRONOS*flex*-400

The core of the test system is the modularly expandable imc CRONOS*flex* measurement device. It consists of the CRFX-400 base unit and can be easily expanded with additional measurement amplifier modules. The base unit allows for an aggregate sampling rate of up to 400 kSamples/s.

In addition, the base unit offers:

- Integrated real-time analysis and control functionality with imc Online FAMOS.
- TCP/IP Ethernet interface for the connection of a PC.
- Built-in flash memory and optional hard drive.
- Connection possibility for GPS (time and position information)
- Self-starting and data backup function in case of power failure.

imc CRONOS*flex* measurement modules

The imc CRONOS*flex* series offers a wide range of amplifier types with up to 100 kS/s per channel, integrated signal conditioning and sensor supply. The system supports almost every sensor. Whether analog signals, incremental encoders, digital process variables or data from fieldbus systems such as CAN, CAN FD, PROFIBUS, PROFINET – all are acquired synchronously by the imc CRONOS*flex*. Thanks to the robust design, the measurement system ensures precise results even under difficult ambient conditions – e.g., high temperature fluctuations.

Fig. 4: imc CRFX/ICPU2-8 module ©imc

Special features of the ICPU2-8 module

The ICPU2-8 is a broadband measurement amplifier. It is typically applied in noise and vibration analysis and acceleration measurements.

Measurement of:

- IEPE/ICP sensors (current-fed 4 mA)
- Voltage (AC and DC coupling)
- Direct connection of ICP-compatible sensors (ICP™, DELTATRON®, PIEZOTRON® sensors) takes place via BNC connectors.

Highlights:

- High signal bandwidth of up to 48 kHz
- Finely adjustable input voltage range (from ±5 mV to ±50 V)
- Input coupling switchable via software: DC, AC, AC with current supply
- Each channel with its own adjustable filter (e.g., anti-aliasing filter) and simultaneous A/D converter
- Supports *imc Plug & Measure* conforming to IEEE 1451.4 (Class I mixed mode interface)

Fig. 5: Click-mechanism – connects modules electrically and mechanically ©imc

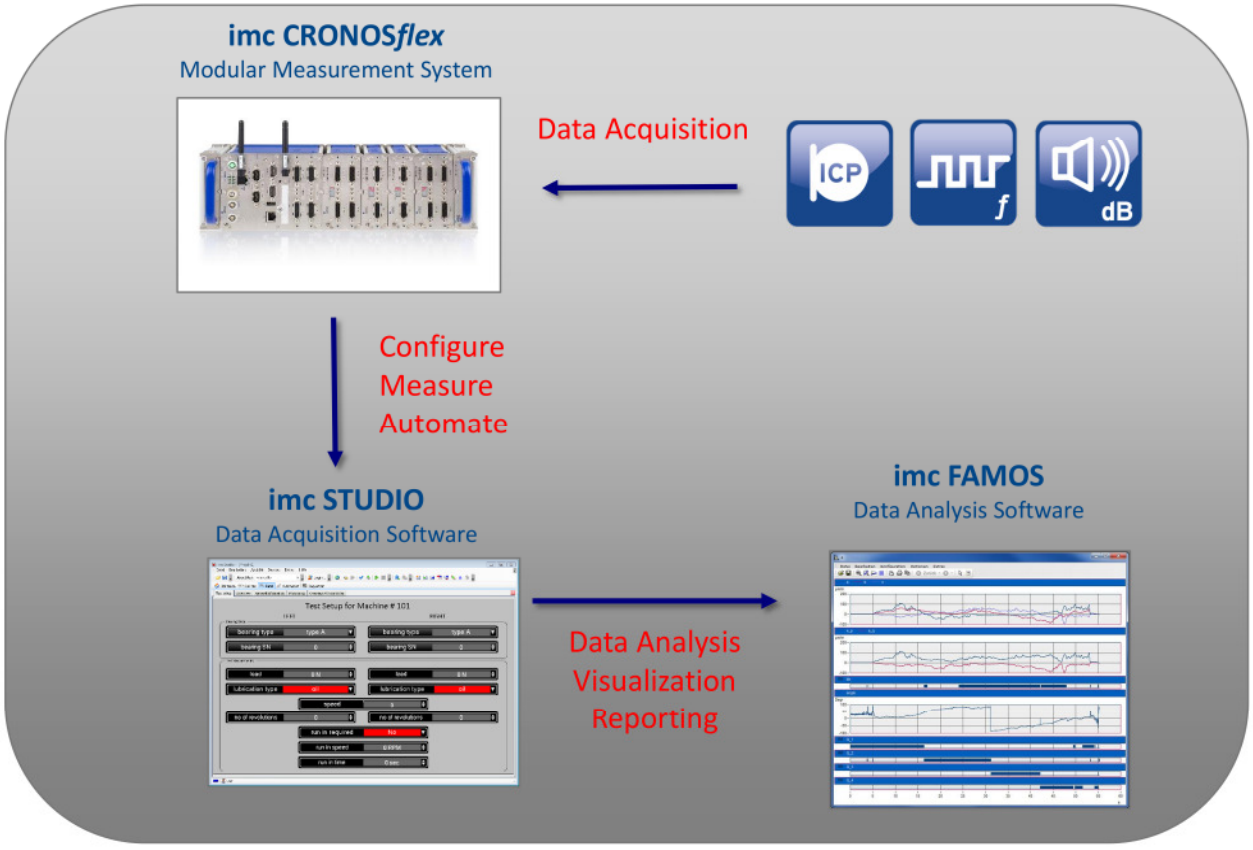

Fig. 5: imc measurement devices and software used for NVH Analysis ©imc

Data analysis with imc FAMOS

Analysis and prediction

The signal analysis software imc FAMOS provides engineers with the versatile tools necessary to visualize and analyze measurement data and automate routines and complex tasks – from data import to test report.

imc FAMOS provides multiple functions for analyzing time and frequency domain data. To analyse and optimize the cutter performance and service life, imc FAMOS vibration signal analysis, transfer function and coherence analysis were applied.

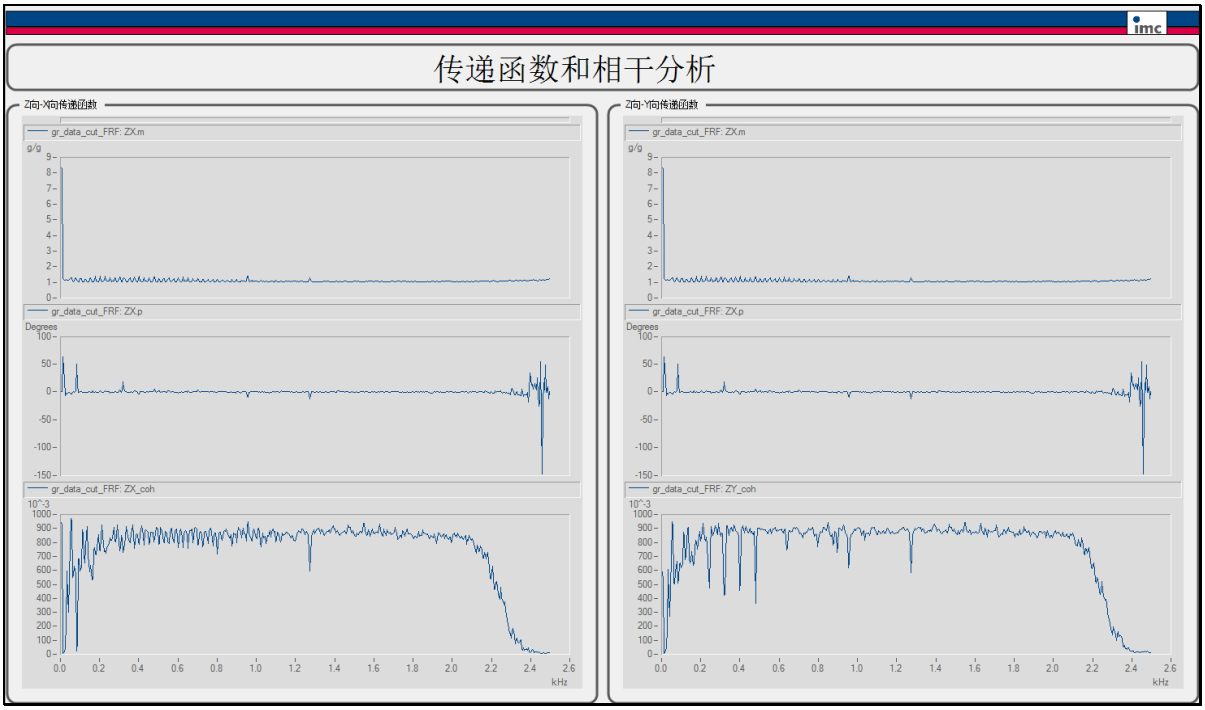

Fig. 6: Transfer function and coherence analysis with imc FAMOS ©imc

Data visualization with imc STUDIO

Automated testing process, visualization and reporting

imc STUDIO provides test engineers with a modular architecture that can easily and quickly configure data acquisition tasks. Through the design of different test panels, a complete automated test procedure, data analysis and evaluation can be established and the current test report can be generated. Dialog-controlled, these panels guide the user through the entire measurement cycle. Since different parameters result in different vibration levels and frequency components, the panel of the imc STUDIO design can also enter the type, material, structure, model of the cutter, as well as information recording conditions such as rotor rpm and feed speed. According to the customer's experience value, the vibration level can be monitored in real time and the limit values can be compared. If the limit is exceeded, an alarm will be given. All measurement data can be viewed and evaluated online and over multiple PCs. With the imc curve window, a tool is available that provides user-defined 2D and 3D displays of the measurement data during the measurement. Real-time measurement cursors, markers and texts in the curve window allow direct checking of the measured data during record-

ing. It is also possible to comment on events during a measurement by means of tagging functions as well as text and speech input. After an automated testing process, a cutter vibration test report can be automatically generated based on the desire to understand the recorded requirements.

Fig. 7: GUI for automated testing in imc STUDIO @imc

Fig. 8: GUI for automated testing in imc STUDIO @imc

Conclusion

Despite the harsh working environment and limited space available, imc measurement systems provide reliable, highly flexible and easy acquisition, control, and analysis operations.

The imc CRONOS*flex* measurement system provides fast and reliable data acquisition. In combination with imc STUDIO, the automated test procedure software, and imc FAMOS, the fast post-processing data analysis software, it can be integrated into a real-time intelligent solution for vibration monitoring of the cutter.

For noise and vibration analysis, imc CRONOS*flex*, imc STUDIO and imc FAMOS are powerful tools at your disposal. Ready-to-go analysis functions such as FFT, order tracking, octave analysis, acoustics and much more will provide finished results during running measurements. Complete analysis packages also offer less experienced users safe and straightforward operations.

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Our customers from the fields of automotive engineering, mechanical engineering, railway, aerospace and energy use imc measurement devices, software solutions and test stands to validate prototypes, optimize products, monitor processes and gain insights from measurement data. As a solution provider, imc offers their customers an attractive and comprehensive range of services. These include project consulting, contracted measurements, data evaluation, specialist deployment, customer-specific software development and system integration. imc consistently pursues its claim of providing services for “productive testing”.

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