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"Empirical mode decomposition of pressure signal for health condition monitoring in waterjet cutting"

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Abstract: Waterjet/abrasive waterjet cutting is a flexible technology that can be exploited for different operations on a wide range of materials. Due to challenging pressure conditions, cyclic pressure loadings, and aggressiveness of abrasives, most of the components of the ultra-high pressure (UHP) pump and the cutting head are subject to wear and faults that are difficult to predict. Therefore, the continuous monitoring of machine health conditions is of great industrial interest, as it allows implementing condition-based maintenance strategies, and providing an automatic reaction to critical faults, as far as unattended processes are concerned. Most of the literature in this frame is focused on indirect workpiece quality monitoring and on fault detection for critical cutting head components (e.g., orifices and mixing tubes). A very limited attention has been devoted to the condition monitoring of critical UHP pump components, including cylinders and valves. The paper investigates the suitability of the water pressure signal as a source of information to detect different kinds of fault that may affect both the cutting head and the UHP pump components. We propose a condition monitoring approach that couples empirical mode decomposition (EMD) with principal component analysis to detect any pattern deviation with respect to a reference model, based on training data. The EMD technique is used to separate high-frequency transient patterns from low-frequency pressure ripples, and the computation of combined mode functions is applied to cope with the mode-mixing effect. Real industrial data, acquired under normal working conditions and in the presence of actual faults, are used to demonstrate the performances provided by the proposed approach.

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"Profile monitoring via sensor fusion: the use of PCA methods for multi-channel data"

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Abstract: Continuous advances of sensor technology and real-time computational capability are leading to data-rich environments to improve industrial automation and machine intelligence. When multiple signals are acquired from different sources (i.e. multi-channel signal data), two main issues must be faced: (i) the reduction of data dimensionality to make the overall signal analysis system efficient and actually applicable in industrial environments, and (ii) the fusion of all the sensor outputs to achieve a better comprehension of the process. In this frame, multi-way principal component analysis (PCA) represents a multivariate technique to perform both the tasks. The paper investigates two main multi-way extensions of the traditional PCA to deal with multi-channel signals, one based on unfolding the original data-set, and one based on multi-linear analysis of data in their tensorial form. The approaches proposed for data modelling are combined with appropriate control charting to achieve multi-channel profile data monitoring. The developed methodologies are demonstrated with both simulated and real data. The real data come from an industrial sensor fusion application in waterjet cutting, where different signals are monitored to detect faults affecting the most critical machine components.

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