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Implementation of Correlation-Based Data Analysis as a Preliminary Stage for the Prediction of Geometric Dimensions Using Machine Learning in the Forming of Car Seat Rails

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Abstract : When forming metallic materials, fluctuations in material properties, process conditions and wear lead to deviations in the component geometry. Several hundred features sometimes need to be measured, especially in the case of functional and safety-relevant components. These can only be measured offline due to the large number of features and the accuracy requirements. The risk of producing components outside the tolerances is minimized but not eliminated by the statistical evaluation of process capability and control measurements. The inspection intervals are based on the acceptable risk and are at the expense of productivity but remain reactive and, in some cases, considerably delayed. Due to the considerable progress made in the field of condition monitoring and measurement technology, permanently installed sensor systems in combination with machine learning and artificial intelligence, in particular, offer the potential to independently derive forecasts for component geometry and thus eliminate the risk of defective products - actively and preventively. The reliability of forecasts depends on the quality, completeness and timeliness of the data. Measuring all geometric characteristics is neither sensible nor technically possible. This paper, therefore, uses the example of car seat rail production to discuss the necessary first step of feature selection and reduction by correlation analysis, as otherwise, it would not be possible to forecast components in real-time and inline. Four different car seat rails with an average of 130 features were selected and measured using a coordinate measuring machine (CMM). The run of such measuring programs alone takes up to 20 minutes. In practice, this results in the risk of faulty production of at least 2000 components that have to be sorted or scrapped if the measurement results are negative. Over a period of 2 months, all measurement data (> 200 measurements/ variant) was collected and evaluated using correlation analysis. As part of this study, the number of characteristics to be measured for all 6 car seat rail variants was reduced by over 80%. Specifically, direct correlations for almost 100 characteristics were proven for an average of 125 characteristics for 4 different products. A further 10 features correlate via indirect relationships so that the number of features required for a prediction could be reduced to less than 20. A correlation factor >0.8 was assumed for all correlations.

Keywords : long-term SHM, condition monitoring, machine learning, correlation analysis, component prediction, wear prediction, regressions analysis
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