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A NOVEL METHODOLOGY FOR DETECTING FOREIGN OBJECT DAMAGE ON COMPRESSOR BLADING

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Foreign Object Damage (FOD) to compressor airfoils is a common problem in operating aircraft engines that occurs when objects or debris are sucked into the engines. Especially small surface defects or impact damage ($\approx 100\mu m$ depth) caused by smaller objects can be problematic, as it only becomes noticeable during engine maintenance process, but can have a strong influence on the fatigue strength and service life of individual airfoils.

Usually the blade and vane inspection during maintenance is carried out by visual examinations and measurements with callipers and other special equipment in order to detect impact damage, deformation and wear. The inspection findings are individual assessed and as a result the airfoils are accepted, repaired or replaced. This manual inspection process needs a considerable amount of time and has therefore a significant optimization potential by the means of automatization. This paper present a novel methodology to automatic detect FOD on compressor airfoils. For the investigation and validation, over 1000 used compressor blades and vanes were digitized on site with a high precision optical 3D scanning system.

A first approach is based on a machine learning algorithm. The idea is the surface segmentation of the digitized airfoil into typical effected areas such as the leading edge (LE), trailing edge (TE), or pressure side (PS), whereas irregularities during the segmentation can be a sign for FOD. For a second approach, the surface curvature of the airfoil is considered. Locally limited regions with high curvature and concave shapes are sought, as an indication for FOD. The required FOD parameters position and depth for the airfoil condition assessment are calculated for the detected FOD of both approaches. The results of both approaches are compared to each other and are validated against the results of a commercial software tool, which uses the approach of digital stoning to create surface defect maps. Furthermore, the results are verified by manually examining the blade scans.
In the case of small FOD ($100\mu m - 500\mu m$ depth), both approaches generate meaningful results. In terms of larger FOD, like a deformation (bend) caused by a larger object, both approaches have difficulties detecting it. The reason for this is the more subtle change of geometry compared to smaller FOD.
This problem can be compensated by parametrization of the scanned airfoils with a section based approach using NACA like parameters. Significant and unusual changes of specific airfoil parameters (e.g. stagger angle and chord length) over the blades height indicate large FOD.

Keywords: foreign object damage, surface defects, impact detection, deterioration, wear, machine learning