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# Vibration response of spalled rolling element bearings: Observations, simulations and signal processing techniques to track the spall size

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Fatigue in rolling element bearings, resulting in spalling of the races and/or rolling elements, is the most common cause of bearing failure. The useful life of the bearing may extend considerably beyond the appearance of the first spall and a premature removal of the bearing from service can be very expensive, but on the other hand chances cannot be taken with safety of machines or personnel. Previous studies indicated that there might be two parts to the defect vibration signal of a spalled bearing, the first part being originating from the entry of the rolling element into the fault (de-stress) and the second part being due to the departure of the rolling element from the fault (re-stress). This is investigated in this paper using vibration signatures of seeded faults at different speeds. The acceleration signals resulting from the entry of the rolling element into the spall and exit from it were found to be of different natures. The entry into the fault can be described as a step response, with mainly low frequency content, while the impact excites a much broader frequency impulse response. The latter is the most noticeable and prominent event, especially when examining the high pass filtered response or the enveloped signal. In order to enable a clear separation of the two events, and produce an averaged estimate of the size of the fault, two approaches are proposed to enhance the entry event while keeping the impulse response. The first approach (joint treatment) utilizes pre-whitening to balance the low and high frequency energy, then octave band wavelet analysis to allow selection of the best band (or scale) to balance the two pulses with similar frequency content. In the second approach, a separate treatment is applied to the step and the impulse responses, so that they can be equally represented in the signal. Cepstrum analysis can be used to give an average estimate of the spacing between the entry and impact events, but the latter can also be assessed by an arithmetic estimation of the mean and standard deviation of the event separation for a number of realizations, in particular for the second approach. In order to determine the effects of various simulations and signal processing parameters on the estimated delay times, the entry and exit events were simulated as modified step and impulse responses with precisely known starting times. The simulation was also found useful in pointing to artefacts associated with the cepstrum calculation, which affect even the simulated signals, and have thus prompted modifications of the processing of real signals. The results presented for the two approaches give a reasonable approximation of the measured fault widths (double the spacing between the entry and impact events) under different speed conditions, but the method of separate treatment is somewhat better and is thus recommended.



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