Operational vibration of a waterjet focuser as means for monitoring its wear progression

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Research Article

Keywords: Abrasive Waterjet Cutting, Predictive Maintenance, Process Monitoring, Vibration Measurements

Posted Date: April 6th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-316950/v1

Version of Record: A version of this preprint was published at The International Journal of Advanced Manufacturing Technology on July 5th, 2021. See the published version at https://doi.org/10.1007/s00170-021-07534-0.

Abstract

Abrasive waterjet cutting is a competitive manufacturing technology in the aerospace, defense and automotive industries. End-user requirements are currently pushing machine builders to improve the automation of their processes, in an effort to reduce costs and downtimes, as well as increase robustness and stability. On this regard, the waterjet focuser is a critical component, as its fast wear progression requires constant human supervision, for promptly detecting detrimental effects on the cutting performance. This paper describes an innovative approach for in-line monitoring the wear progression of a waterjet focuser, by means of an accelerometer installed on its tip. This result is allowed by two separate studies of the focuser, of which the first investigates the sensitivity of its first mode frequency to the wear progression, whilst the second demonstrates the possibility of tracking said frequency from the in-line vibration signal delivered by the accelerometer, during operation. The presented setup makes use of low-cost sensing hardware that can be easily retrofitted into the design of waterjet focusers. The information delivered is expected to tackle end-user requirements for improved process automation.

Full Text

This preprint is available for download as a PDF.

Figures

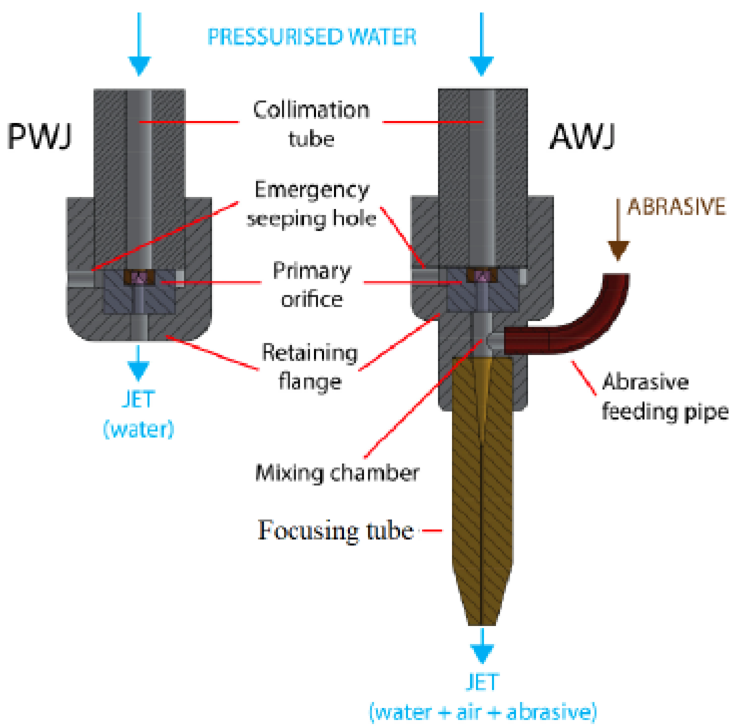

Figure 1

AWJC head (PWJ: pure waterjet; abrasive waterjet) [9].

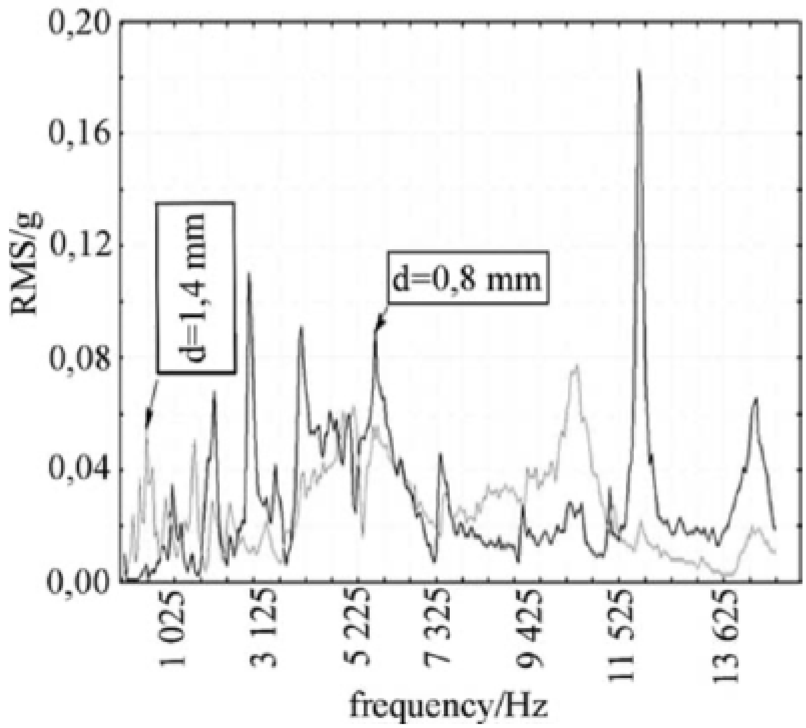

Figure 2

Figure 2. Power spectra of the vibration signals measured on the workpiece, with different focusers [15].

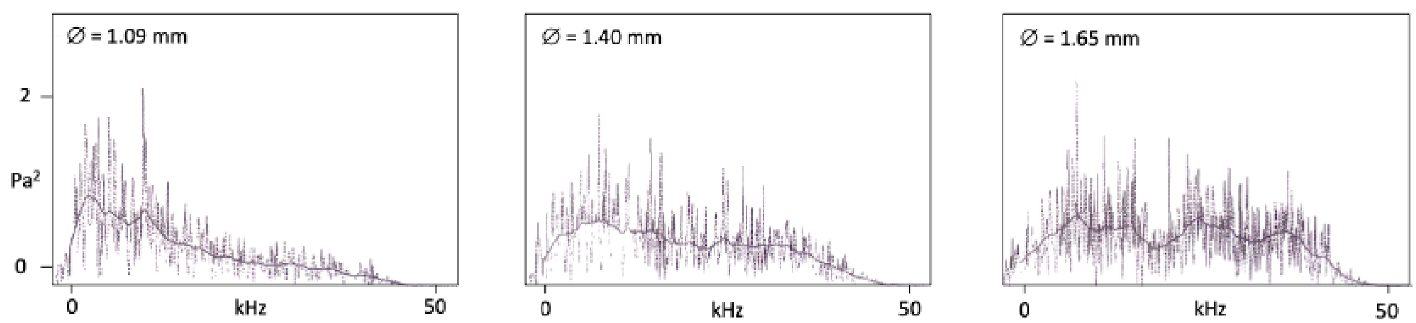

Figure 3

Power spectra of the acoustic signals measured with different focusers [22]; the continuous lines correspond to the ARMA estimates.

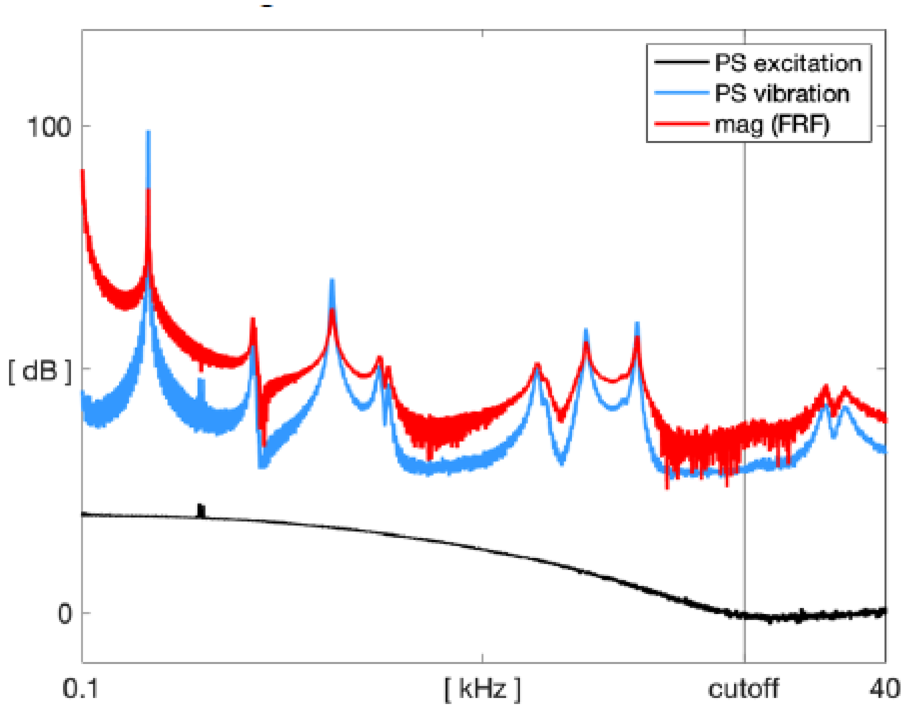

Figure 4

Example of FRF of a system (cantilever beam) and its experimental characterization by means of impact testing.

Figure 5

Left plot: inner bores of the two specimens. Centre plot: experimental setup for impact testing. Right plot: tested specimen and laser spot at tip.

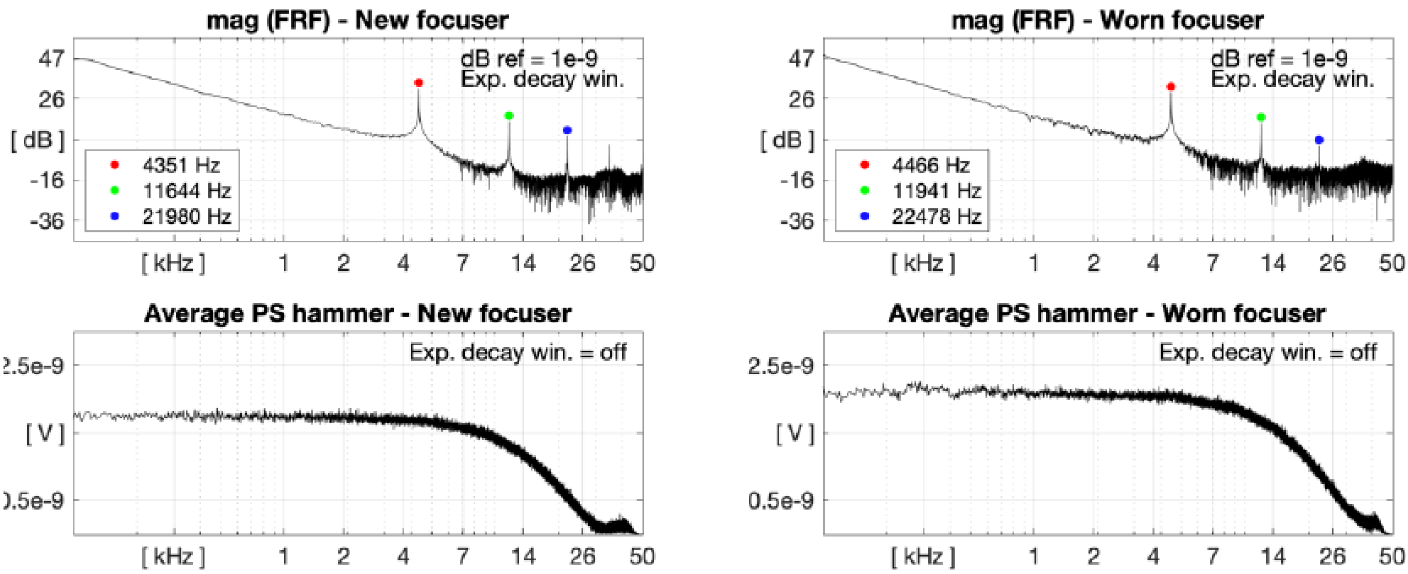

Figure 6

Left plots: new focuser. Right plots: worn focuser. Upper plots: FRFs (magnitude). Lower plots: PSs of input excitations.

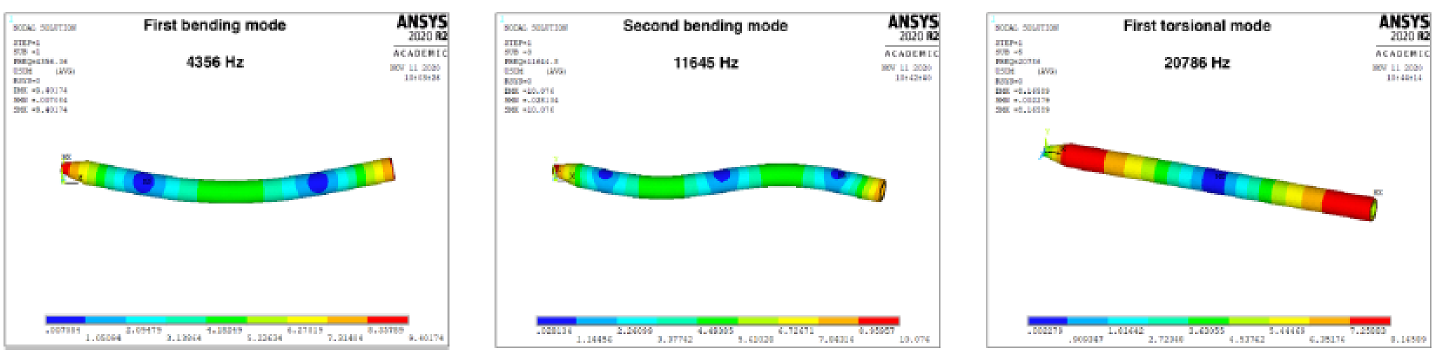

Figure 7

Numerical mode shapes of the unconstrained focuser.

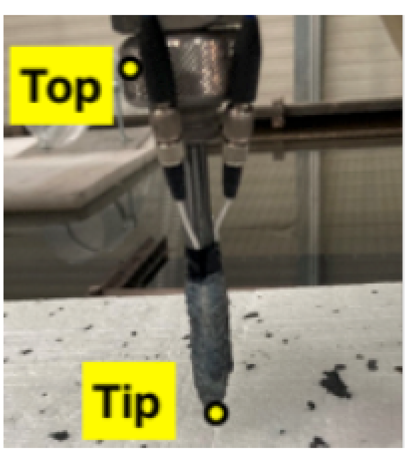

Figure 8

Focuser installed on the cutting head.

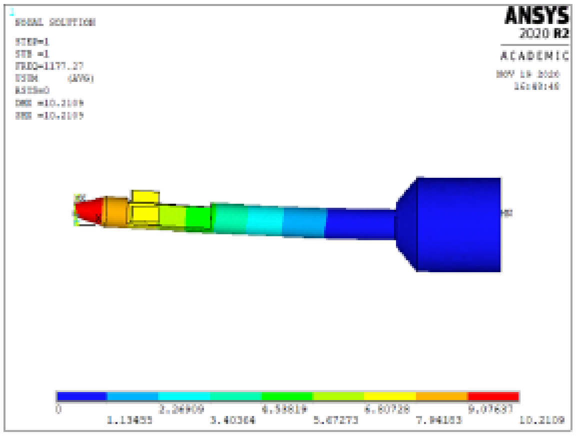

Figure 9

FEM prediction of first mode shape of the constrained focuser.

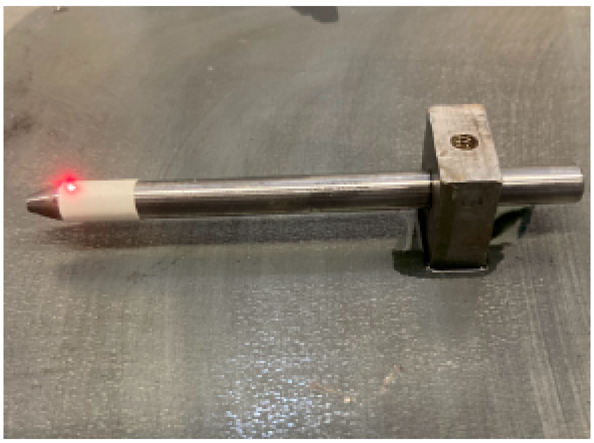

Figure 10

Specimen under cantilever configuration.

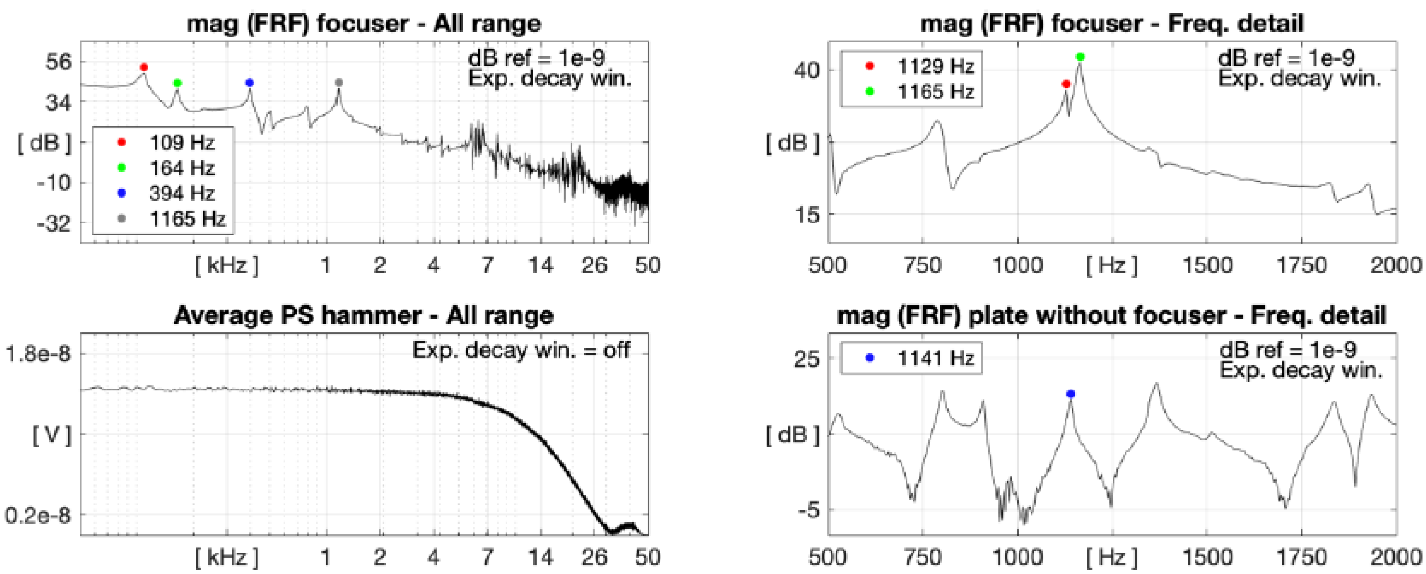

Figure 11

FRF of the constrained specimen.

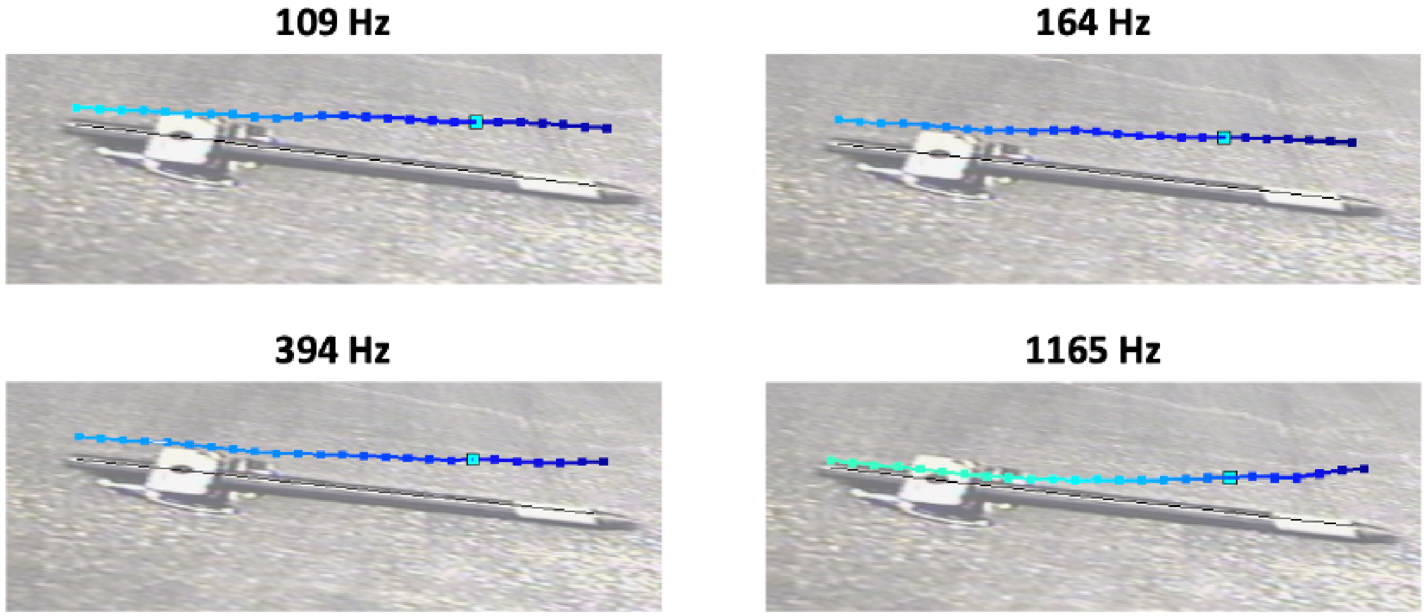

Figure 12

Experimental mode shapes of the constrained specimen.

Figure 13

Focuser with special geometry and onboard accelerometers.

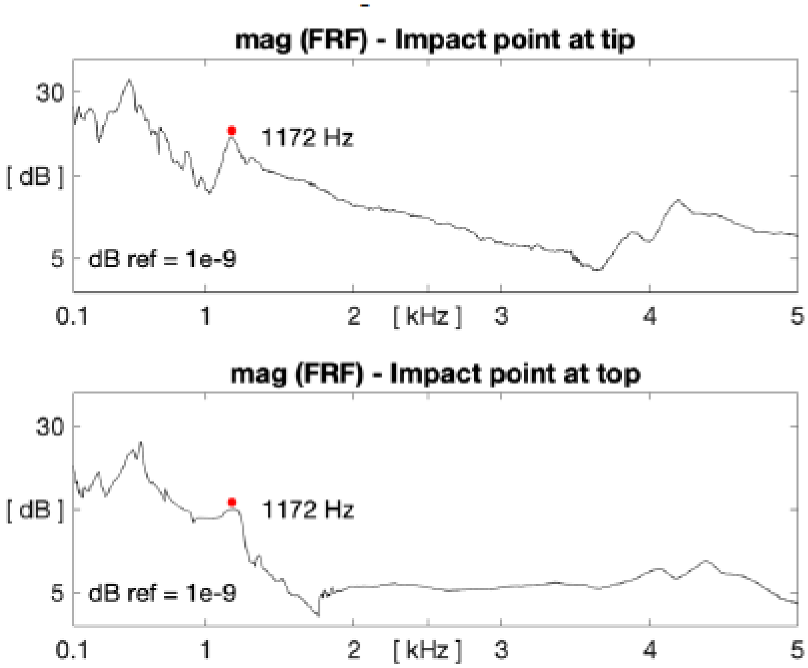

Figure 14

FRFs of the focuser installed on the waterjet cutting machine.

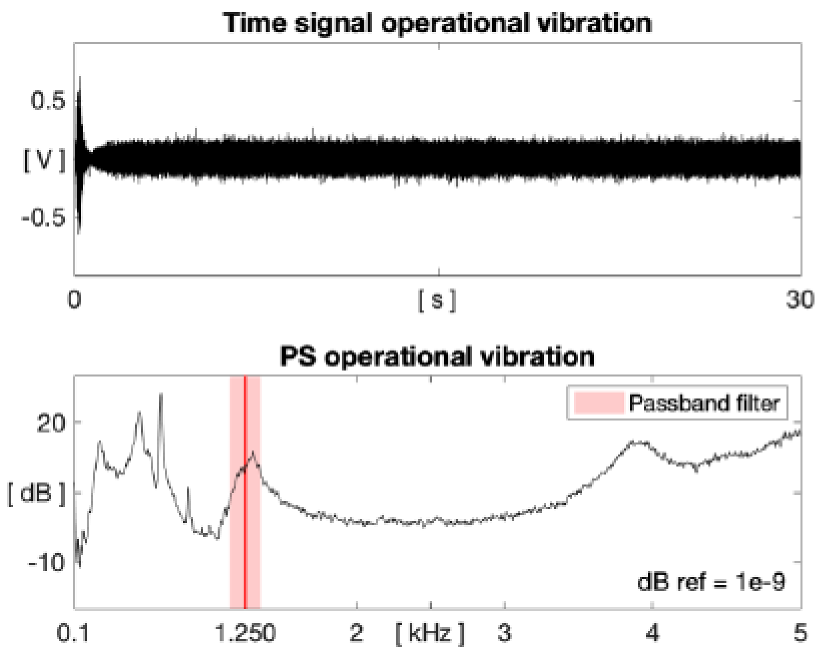

Figure 15

Operational vibration signal delivered by the accelerometer.

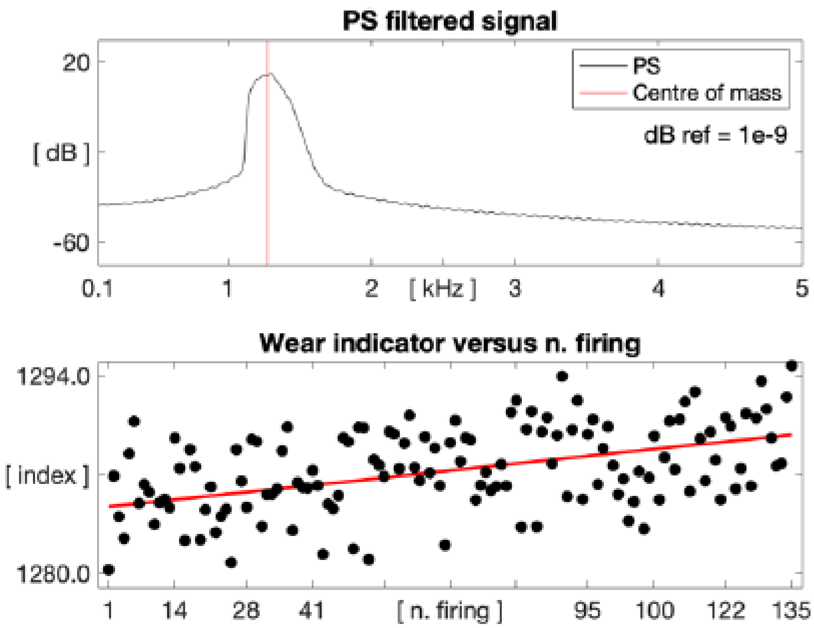

Figure 16

PS of filtered signal.

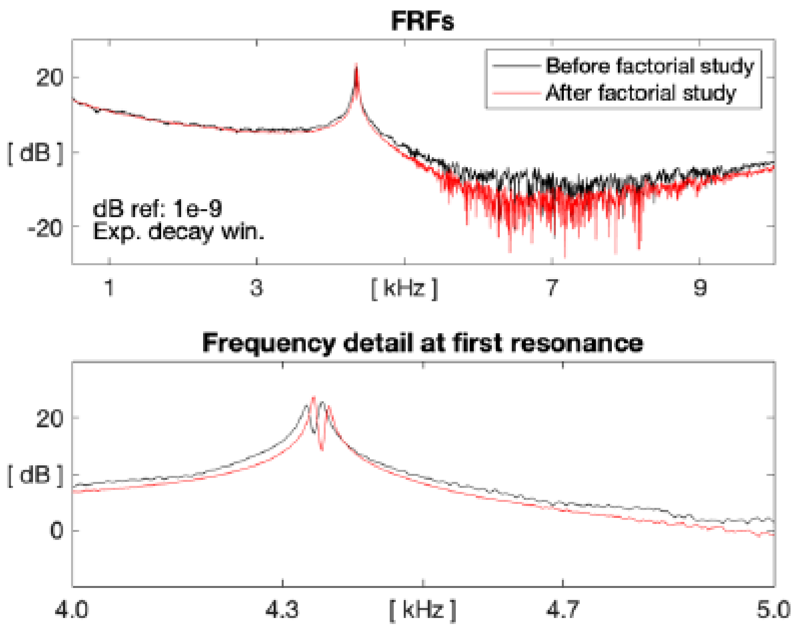

Figure 17

FRFs of the unconstrained focuser before and after the factorial study.