Evaluation of the Applicability of Microphones for Acoustic Process Monitoring

Degree programme: BSc in Micro- and Medical Technology
Specialisation: Sensor technology
Thesis advisor: Prof. Dr. Bertrand Dutoit
Industrial partners: Confidential, Confidential

This thesis evaluates the applicability of various microphone technologies for acoustic chatter detection in machining processes. Experimental measurements were performed under real machining conditions to assess robustness, signal quality, and integration effort. Based on these results, a recommendation will be made for a sensor solution suitable for long-term industrial use.

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Introduction

Acoustic sensing is a promising method for detecting chatter in machining processes by capturing acoustic signals. However, exposure to coolant, chips, and vibration causes progressive degradation of microphone performance, limiting long-term reliability.

Goals

This thesis evaluates microphones for robust acoustic process monitoring under realistic conditions, focusing on signal quality, environmental resilience, and integration effort.

Methods

Tests were conducted by milling slots at spindle speeds from 10,000 to 20,000 RPM and an axial depth of cut of 0.75 mm, a condition previously shown to reliably provoke chatter. A new waterproof microphone (Fig. 2 Meas. 1–7) served as the baseline in each test. Additional microphones followed four strategies:

- **Maintenance:** Previously used microphone before (Fig. 2 Meas. 1) and after (Fig. 2 Meas. 2) cleaning.
- **Robustness:** Microphone with enhanced environmental protection (Fig. 2 Meas. 3).
- **Cost Efficiency:** Low-cost microphone with moderate ingress protection (Fig. 2 Meas. 4).
- **Exploratory:** Hydrophone in air (Fig. 2 Meas. 5 & 6) and with contact (Fig. 2 Meas. 7).

Two measurement sets were performed: preprocessed data using the industrial partner's monitoring setup and raw audio recordings.

Results

Most microphones detected chatter similarly to the baseline. The hydrophone outperformed the baseline, despite not being made for airborne use.

To test robustness, all microphones were exposed to coolant for 72 h. A 988 Hz tone was used to measure mean raw amplitude (20 s) at 0 h, after exposure, and after drying. Figure 1 shows each strategy's performance.

Microphone and spindle vibration data were recorded simultaneously. Figure 2 shows how well each microphone captured chatter frequencies.

Conclusion

The hydrophone demonstrated the highest robustness and reliability, maintaining signal integrity under both airborne and contact conditions. This makes it the best choice for long-term use in harsh environments.

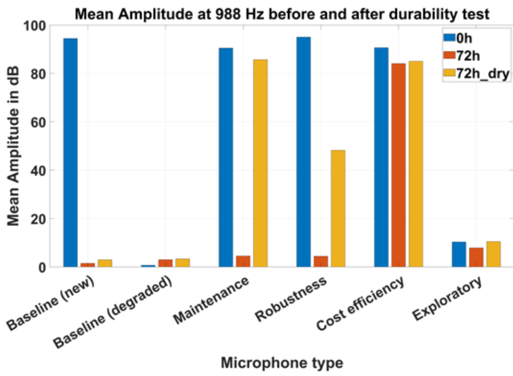

Fig. 1: Mean amplitude at 988 Hz before, after 72 h coolant exposure, and after drying. Hydrophone remained stable.

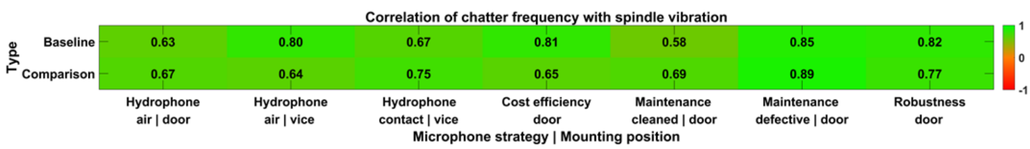

Fig. 2: Correlation between detected chatter and spindle vibration. The Hydrophone outperformed the baseline when the hydrophone was mounted in the same position or used in contact mode.