Development of a Reactive Silencer for Turbo Compressors

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Backgrounds

- Turbo compressors generate tonal noise at high frequencies (range 500 – 5000 Hz) that can cause nuisance in the neighbourhood.
- The tonal noise is radiated from the piping and from static equipment such as vessels and heat exchangers.
- Therefore tonal noise should be avoided from entering the pipe system.
Backgrounds

- For these high frequencies, absorption silencers are used based on glass or rock wool or other porous material.
- These silencers appear to fail, and absorption material disappears in the pipe system or into the compressor.
- Therefore, a new silencer concept has been developed based on resonators.
Another silencer concept

- A silencer based on acoustic resonators has been developed.
- The absorption material has been replaced by rows of resonators.
- Each row is tuned to a specific frequency band.
- The frequencies of adjacent bands overlap → a continuous attenuation spectrum.
- A row is made by milling a pattern in a plate.
- A resonator is assembled by stacking a number of plates.
Modelling of a silencer using COMSOL

› For validation of the concept first a small scale silencer was designed and built
› One based on quarter wavelength tubes and one with Helmholtz resonators
› The first design was made with a 1D PULSIM model
› The fine tuning with COMSOL in 3D
› COMSOL predicts the resonance frequencies more accurately
› The 1D model predicts damping more accurately
Complete silencer design

- Line inner diameter 68.2 mm
- Pressure 8.8 bar, $T = 66^\circ C$
- Min. attenuation 5 dB, 700–3000 Hz

First 1D design is made
- Parametric modelling is used
- Min. mesh size 0.010 m, locally even 0.002 m
- $\approx 200$ k cells
- Calculation times $\approx 12$ hours for a frequency step of 1 Hz.

Final result: IL > 10 dB

Insertion loss

- 3D based on Final design 1D
- Final design 1D
- Optimized 3D design
Concluding remarks

› COMSOL has been a powerful tool in analysing silencer designs
› Parametric modelling has been essential. This has improved considerably in the new versions
› Damping is under estimated in COMSOL, but presently better damping modelling is available. Still not straightforward.
› Model size was at the edge by limitation of available memory. This will improve in the future.

Thank you for your attention!