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Optimization of damped cutting tools using finite element method coupled with analytical models

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Agenda

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Background
High quality surface machining

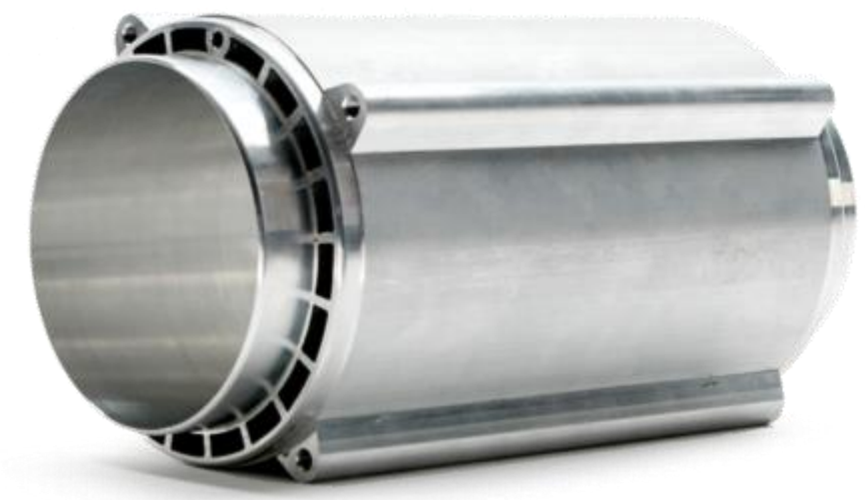
Introduction
Chatter

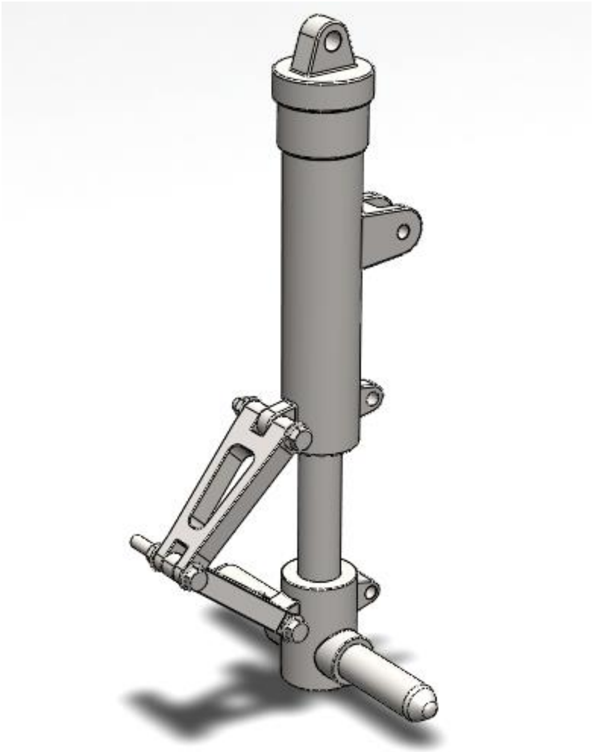
Case
Passive damped boring bar

Modelling methodology
FEA coupled analytical model

Conclusion
Optimization and its results

High-quality surface machining





Components machined by

Boring — Turning — Milling

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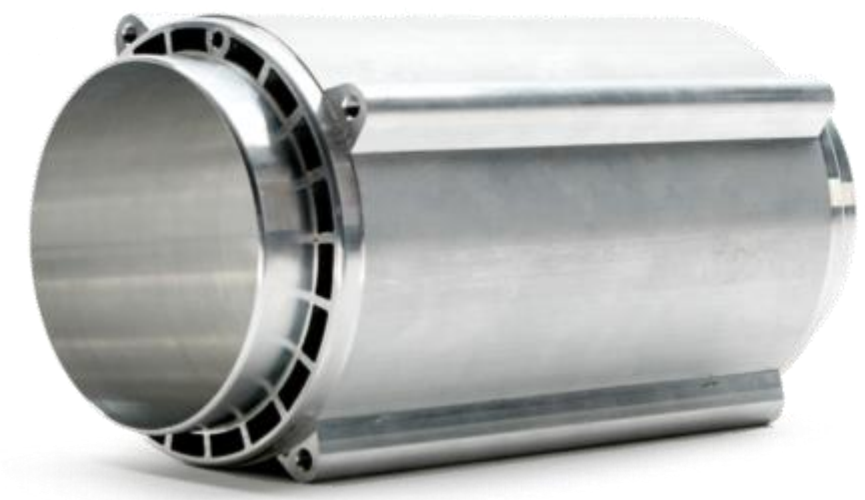
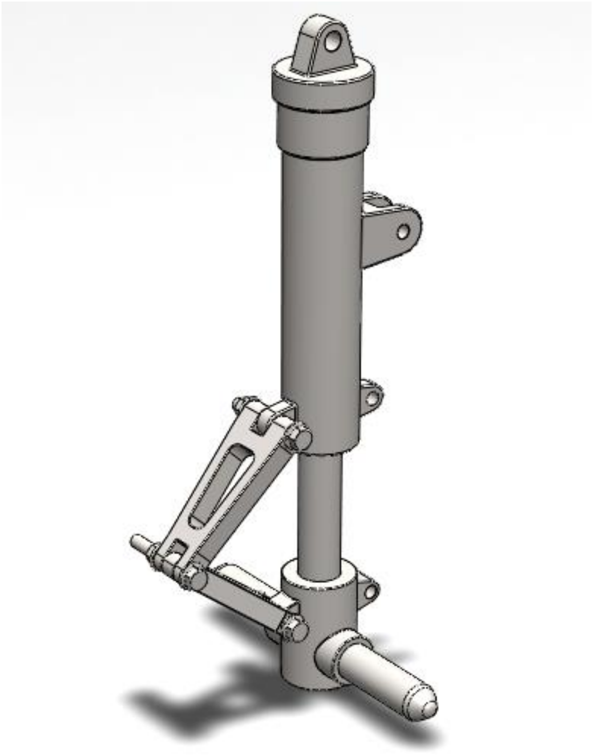
A common problem

High-quality surface machining





Components machined by

Boring — Turning — Milling

A common problem

Chatter

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Introduction to chatter

Vibration

Forced vibration

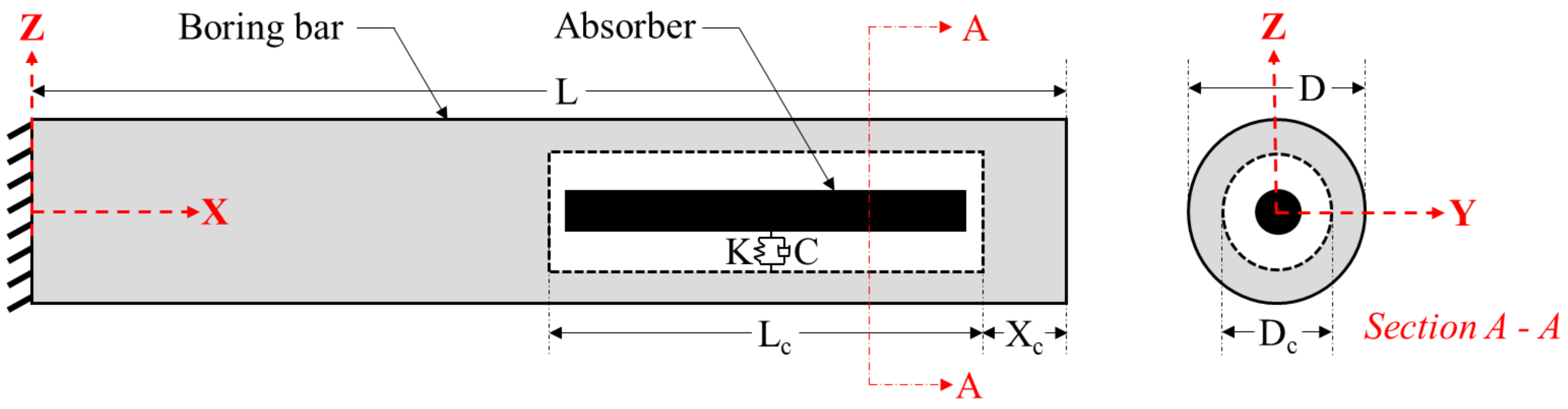
- Caused by external forces
- Resonance occurs when the forcing frequency matches the natural frequency of the system
- Assessed by the magnitude of the system frequency spectrum

Self-excited vibration or Chatter

- Caused by self-excitation due to previously machined surfaces
- Resonance occurs automatically when the system becomes unstable, typically occurring at the chatter frequency
- Assessed by the real part of the system frequency spectrum

Case: Passive damped boring bar

(a) Boring bar

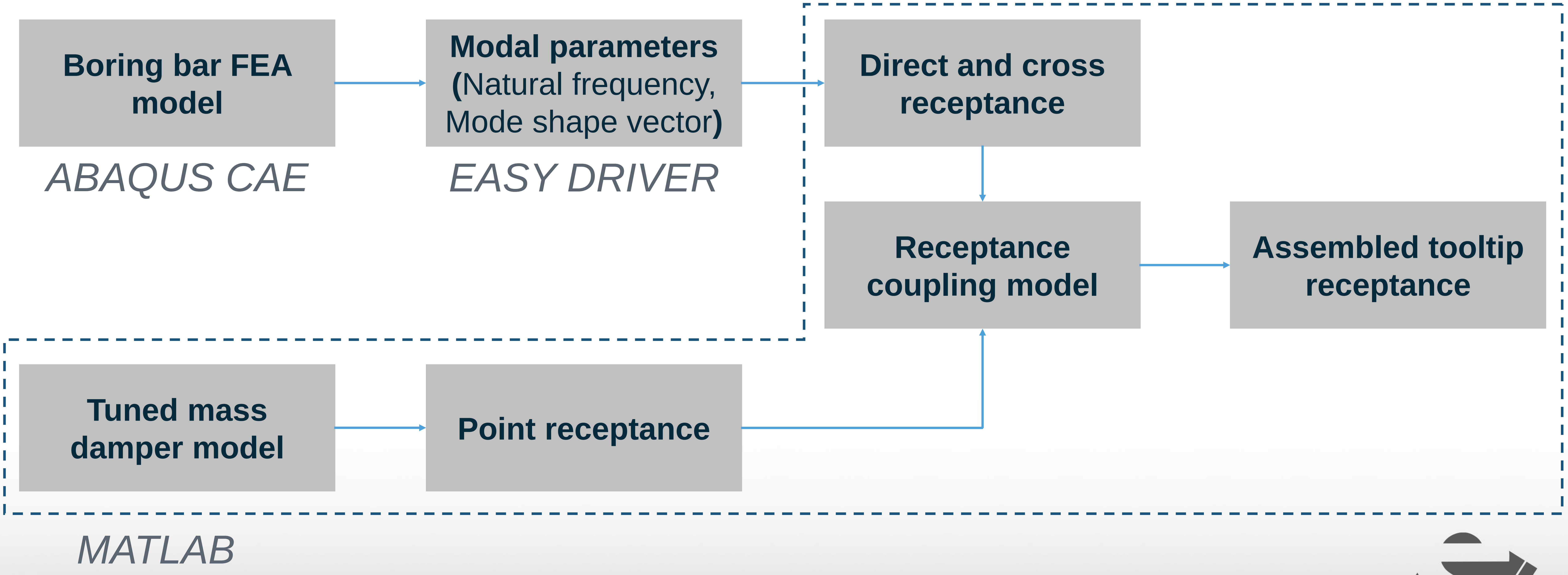


(b) Schematic of the passive damped boring bar

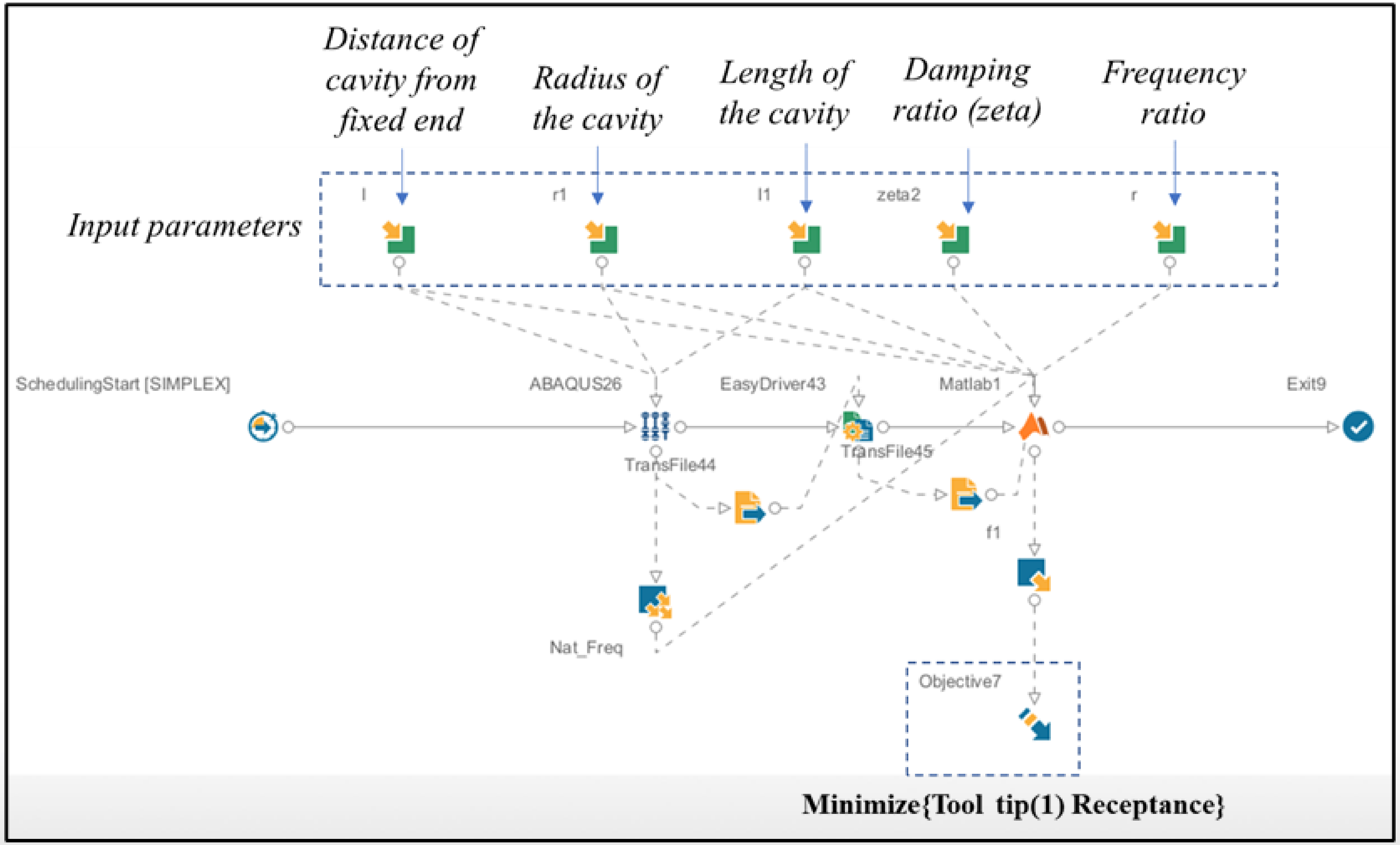
Problems in modelling for optimization

Methods to modelling	Problems
Closed form solution	- Difficult to account complex geometry of the tool - Time-consuming when optimizing the cavity together
Direct numerical modelling	- Difficult to account complex geometry of the tool - Standard algorithms to solve eigenvalue problem increases the computation time
FEA-based harmonic analysis	- Shifting the cavity shifts the nodal point of the TMD spring/dashpot - Time-consuming

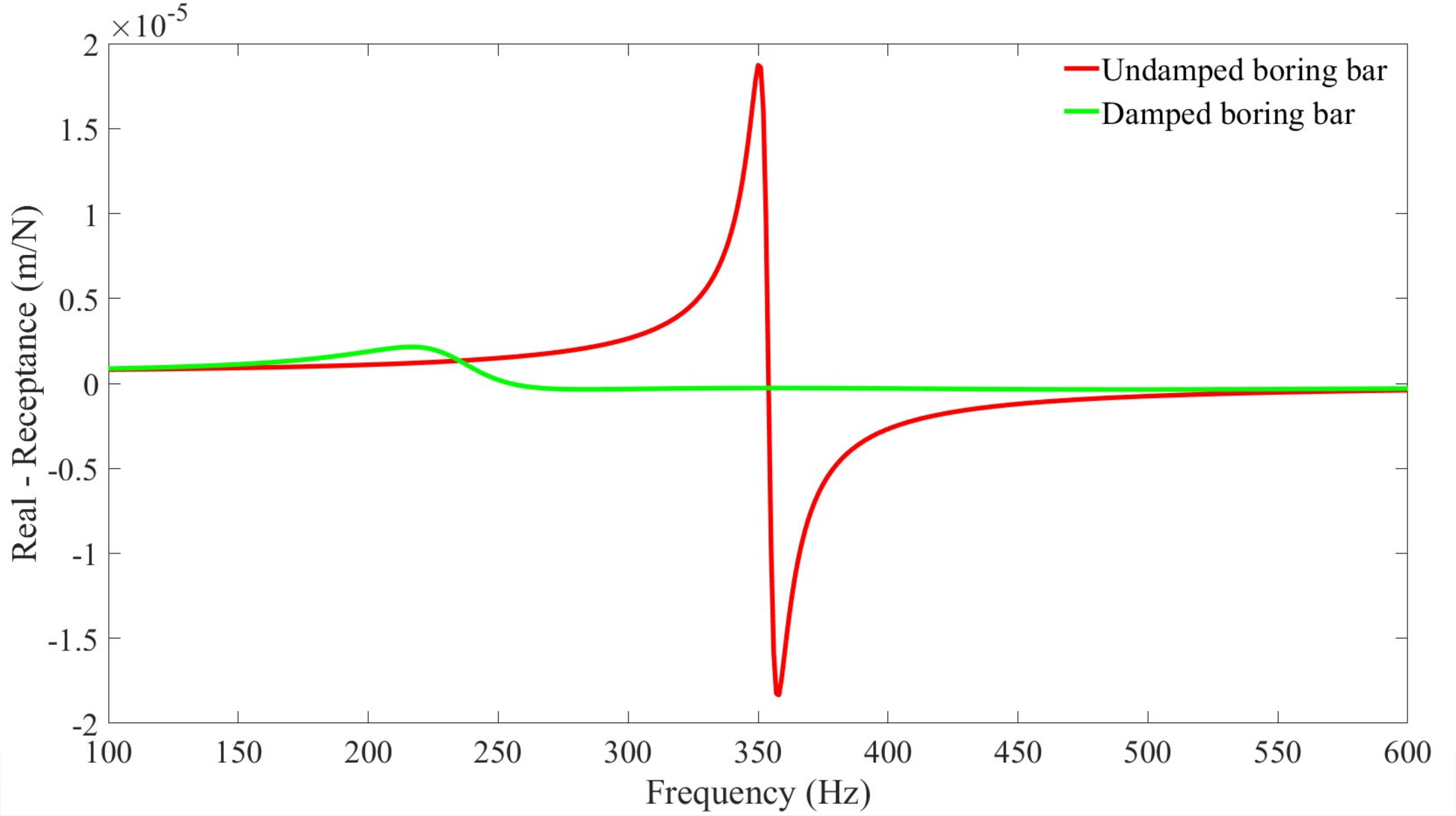
Modelling: FEA coupled analytical model



Optimization flow



Results



- Optimized the cavity design and TMD tuning parameters together
- Computation time for one iteration has taken an average time of 25 seconds

Advantages

- Able to account for the complex geometry of the tool and optimize the tuning parameters, thereby tuning is optimal
- Reduces the overall computation time to perform the optimization
- Standard approach to develop damped cutting tools irrespective of the complex geometry
- Can work for other applications where the TMD needs to be installed inside the structure

Thank you!

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