Design of an optimum vibration absorber for a diamond turning machine

4GC10 Third year mechanical design project

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Design an optimum absorber (tuned mass damper) for a ceramic tool slide of a single point diamond turning machine.
Tuned mass damper (TMD) design:

- Add-on to an existing ceramic beam structure (see next slide)
- Optimally placed, (partially) inside and/or outside of the tool slide
- Provide maximum amount of damping within boundary constraints for extra mass and volume
- Max. two TMD systems are allowed for damping rigid body mode shapes (translation $T_x$ and/or rotation $R_y$) of the tool slide in the aerostatic bearing system
Project assignment

Ceramic tool slide details (CAD picture see next slide):
Project assignment

Ceramic tool slide

CAD picture:
Primary TMD specifications:

- TMD should be made out of metal and viscoelastic material, should be corrosion resistant, reproducible and cost-effective.
- Each TMD should fit in an 80x80 mm footprint, and should add max. 40 mm to the total length (1020 mm) and 15% to the total mass (9 kg) of the tool slide.
- The SiC tool slide can be considered as rigid body, the limiting stiffness results from the air bearings with stiffness $c = 3e6 \text{ N/m}$ and relative damping $\beta = 0.1\%$.
- Since diamond turning forces in X direction are considered critical, the dynamic analysis can be performed in the X-Z plane (see previous slide).

See assignment description for further details.
Project assignment

TMD working principle – Taipei 101 skyscraper Taiwan (508 m): 660 ton TMD steel ball to withstand the typhoon winds and earthquake tremors
Project assignment

TMD working principle:


Notes:
- $\gamma = \text{mass ratio } m_s/m_p$
- $g = \text{dimensionless frequency } f/f_e$
- $\xi = \text{relative damping } b/2\sqrt{mc}$
- $D = \text{magnification factor}$