Design of boring bar damper

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Damped *Silent tools* boring tools from Sandvik

Benefits
- Increase productivity by 50-200%
- Improved surface finish
- Increased safety and reliability of the machining process
- Reducing the cost of machined part

Technical characteristics
- Unique damping mechanism Silent Tools
- Internal coolant throw boring bars body
- Flexibility with a choice between three different ways of organizing tool assembly
- Long range, up to 6 x D

Application
- Boring operations: roughing and finishing
- Capacity to significantly increase cutting parameters thanks to suppress tendencies to oscillation
- Increase in productivity since the length of the overhang 4 x bar diameter

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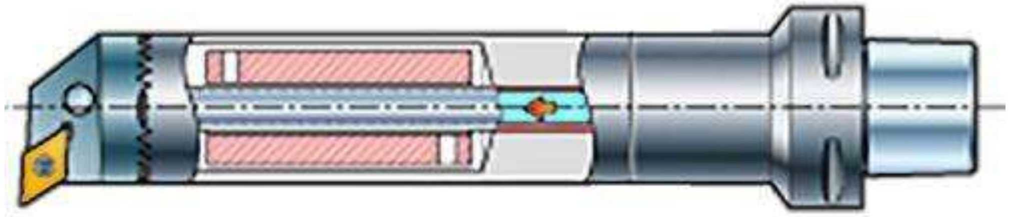
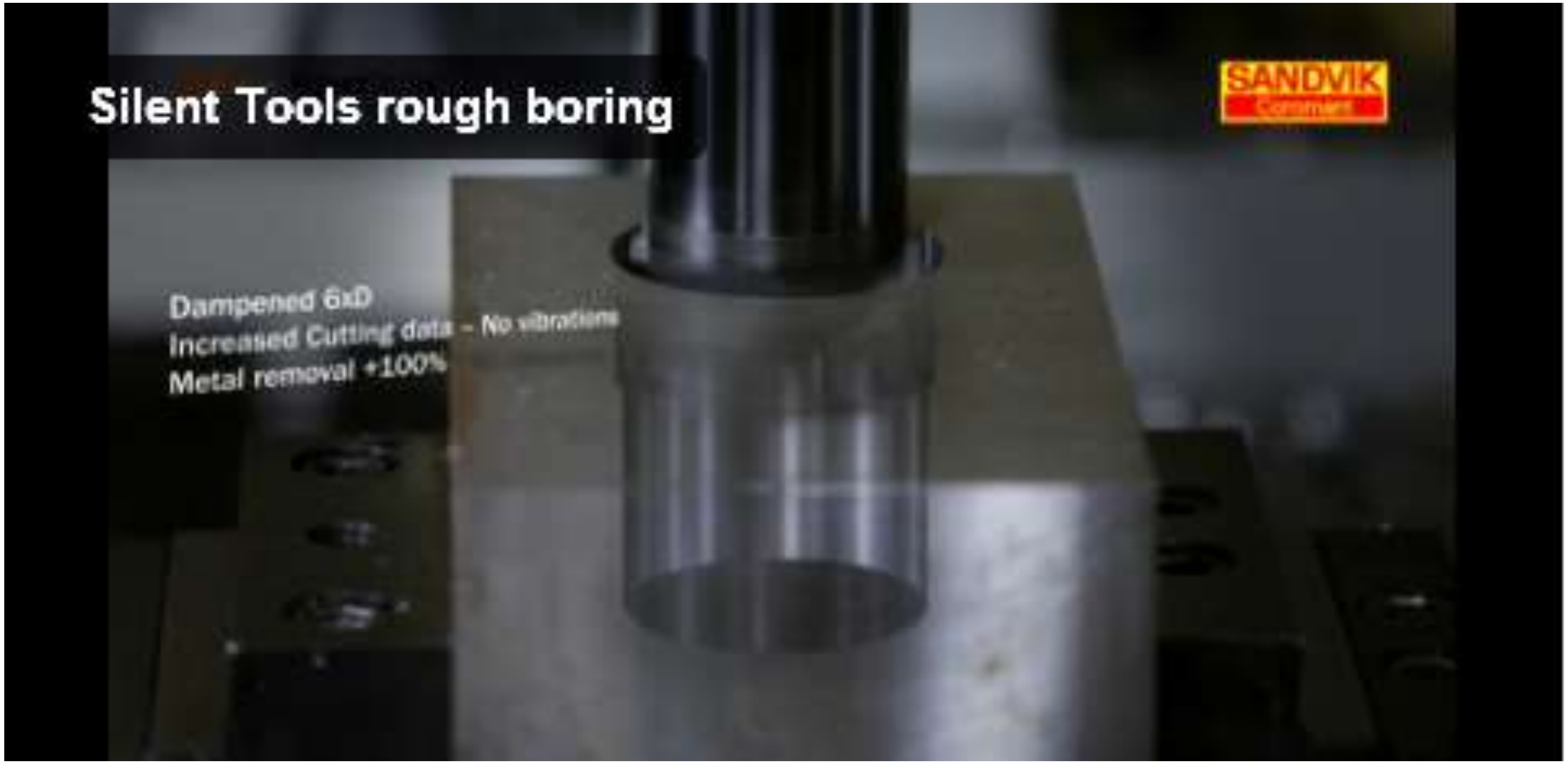
Damped *Silent tools* boring tools from Sandvik



Video demonstration damped boring tools Sandvik



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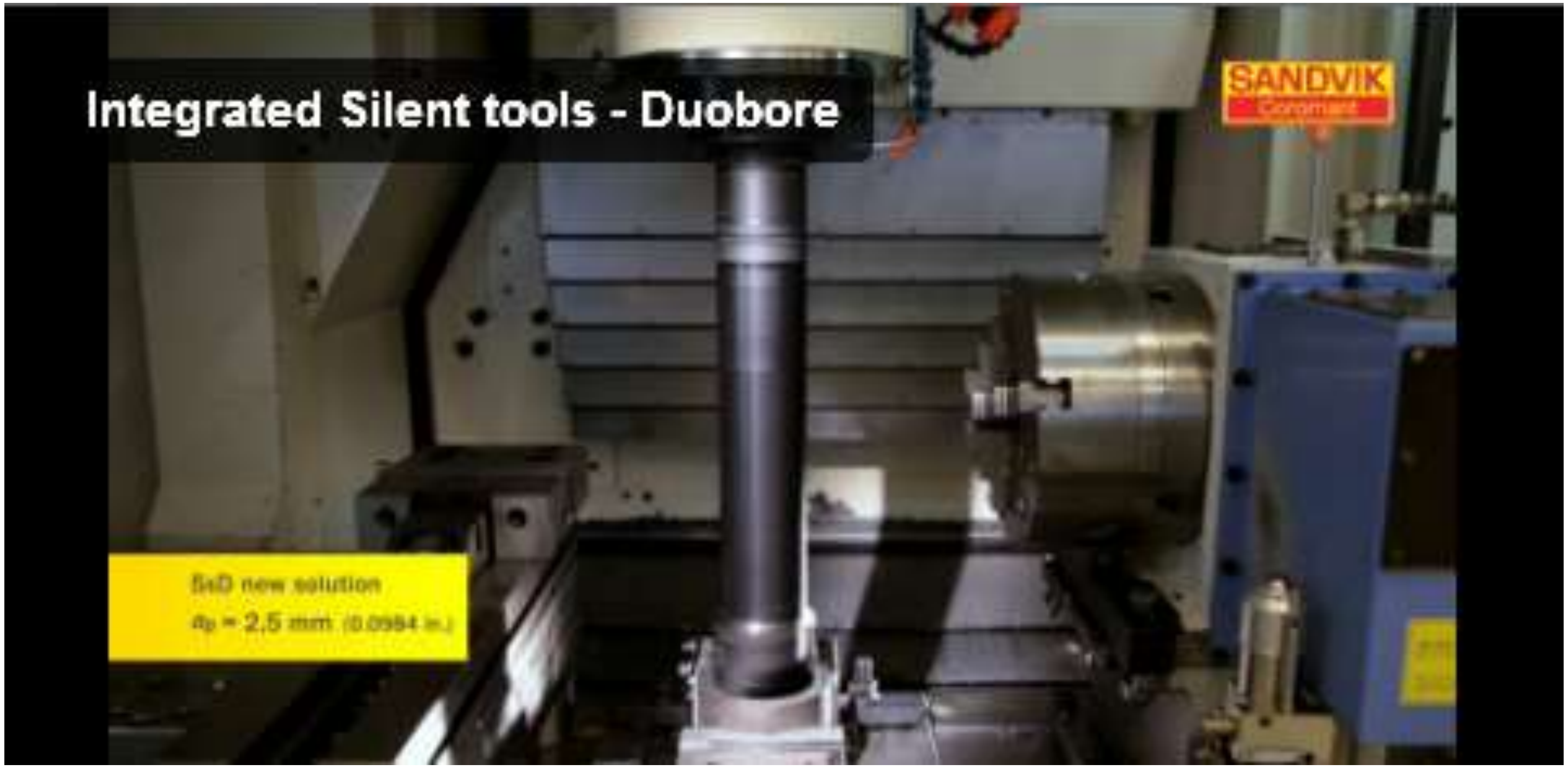

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Video demonstration of milling tools damped Sandvik

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Video demonstration damped turning tools Sandvik

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Task

For boring bar specified dimensions determine:

1. Deflection of the rod (in general),
2. Stiffness of the rod,
3. Self frequency of the rod,
4. Flexibility of the rod.

- Design of boring bar damper and draw drawings of damper.
- They are given the following values : ∅D, ratio L/D, revolutions n, damper neck length l_4

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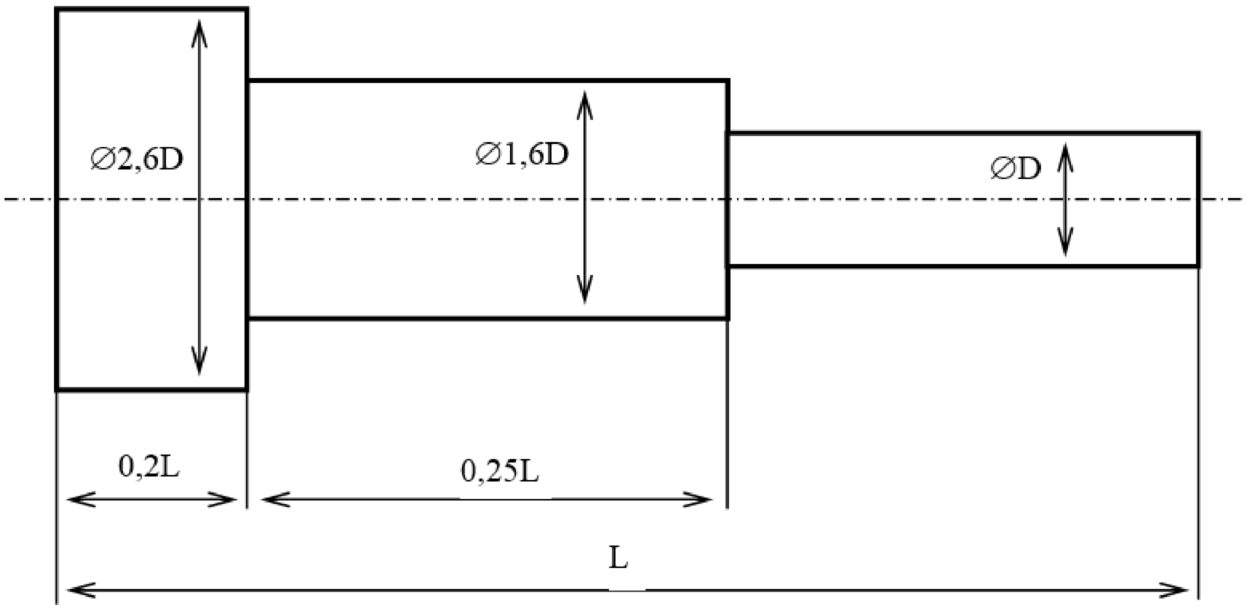
The computational model of bar



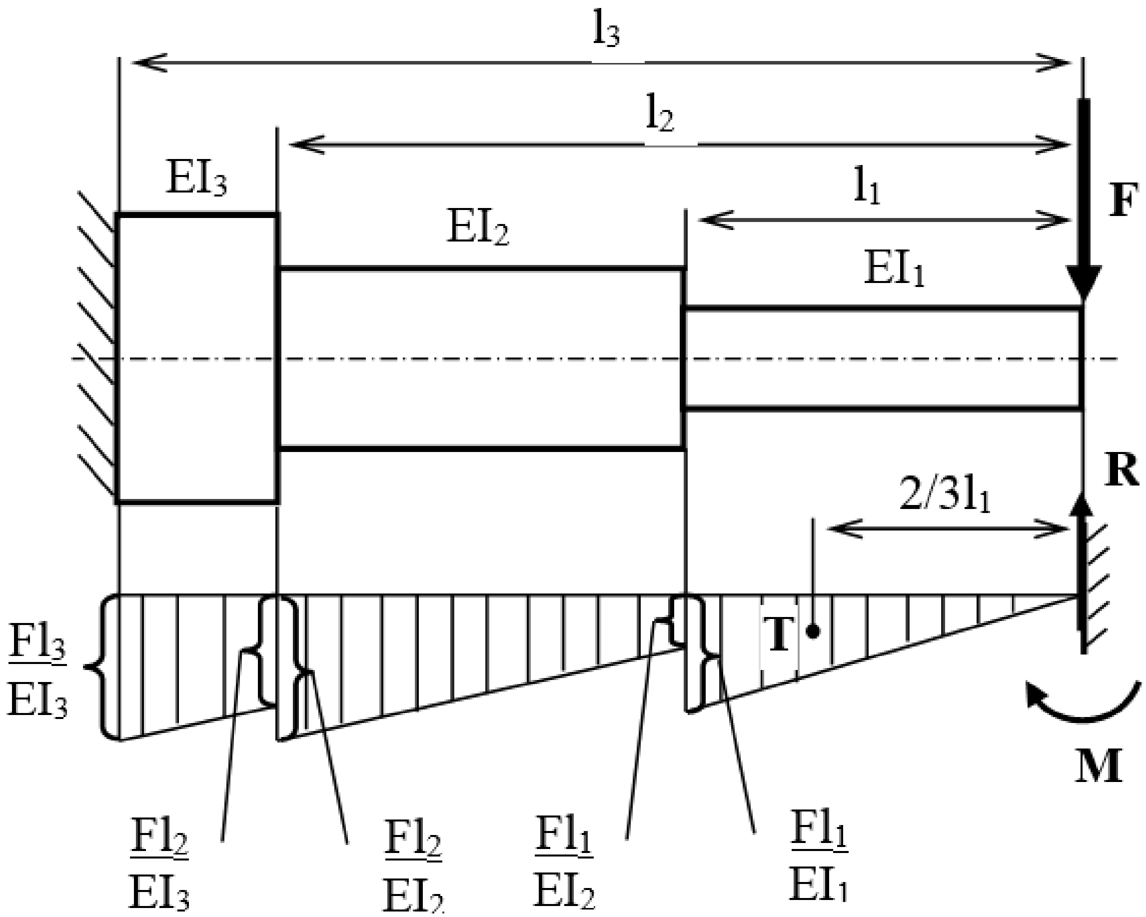
The calculation procedure

Equation for deformation of bar:

torque areas ⇒ imaginary beam

$$y \approx M = M_1 + M_2 + M_3$$

$$M_1 = \frac{Fl_1}{EI_1} \cdot l_1 \cdot \frac{1}{2} \cdot \frac{2}{3} l_1$$



$$y = \frac{F \cdot \left(l_3^3 - l_2^3\right)}{3EI_3} + \frac{F \cdot \left(l_2^3 - l_1^3\right)}{3EI_2} + \frac{F \cdot \left(l_1^3\right)}{3EI_1} \quad ; \quad I = \frac{\pi \cdot D^4}{64}$$

Equation for calculation of the stiffness

$$k = \frac{dF}{dy} = \frac{1}{\left(\frac{l_3^3 - l_2^3}{3EI_3} + \frac{l_2^3 - l_1^3}{3EI_2} + \frac{l_1^3}{3EI_1} \right)}$$

Equation for natural frequency

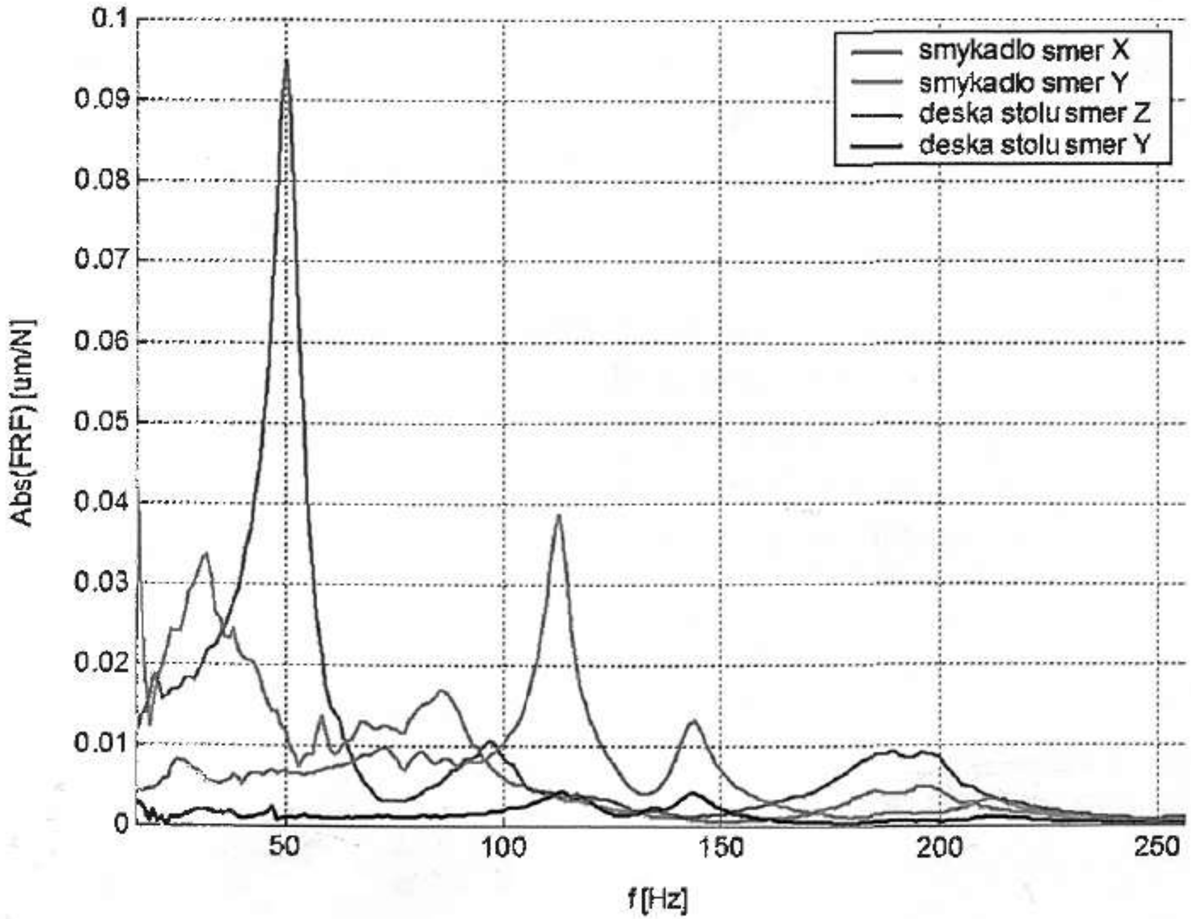
$$\Omega = \sqrt{\frac{k}{m}} \quad \left[s^{-1}\right] \quad ; \quad f = \frac{\Omega}{2\pi} \quad [Hz]$$

$$m = \rho \cdot V = \rho \cdot \frac{\pi}{4} \cdot \left(D_1^2 \cdot l_1 + D_2^2 \cdot (l_2 - l_1) + D_3^2 \cdot (l_3 - l_2) \right)$$

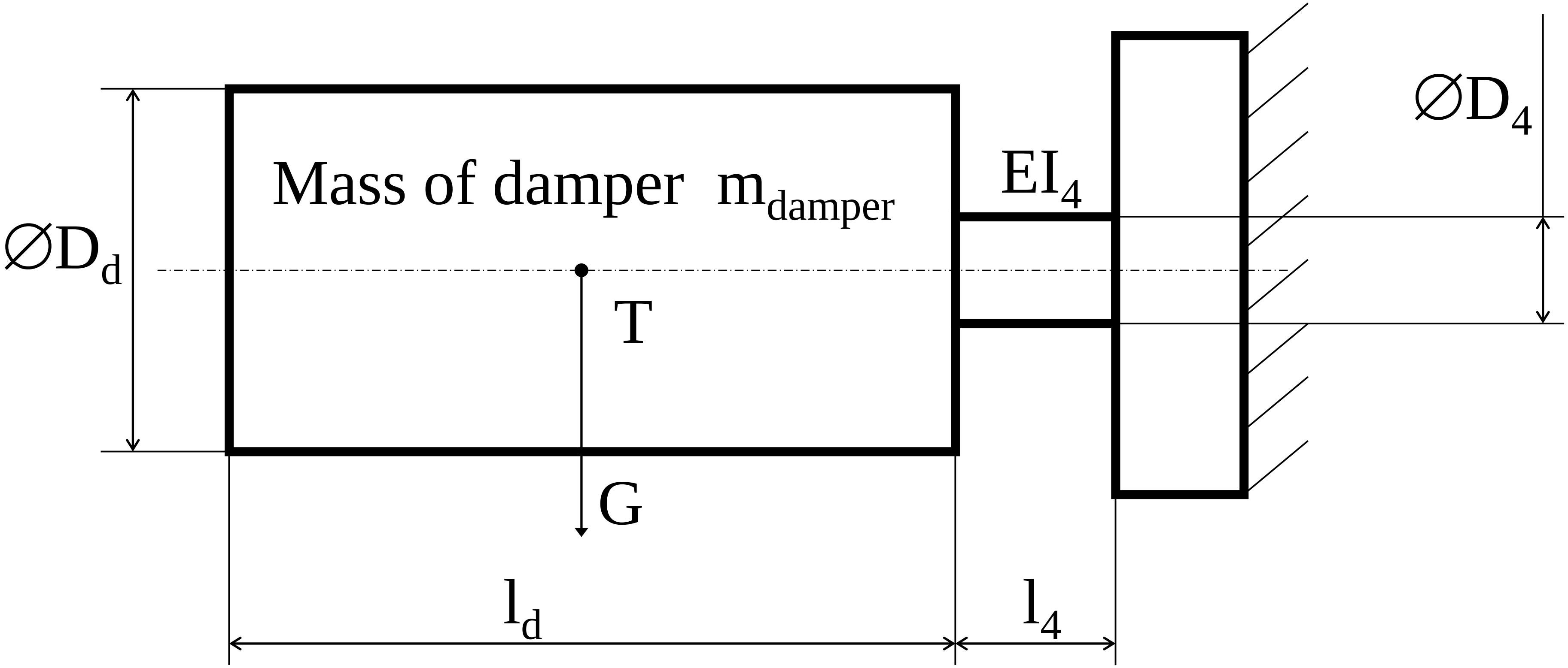
Equation for dynamic flexibility →

$$R_{dc} = \frac{1}{k} \cdot \frac{\Omega^2}{\Omega^2 - \omega^2}$$

Demonstration of dynamic flexibility of the machine's workspace :



Damper design



The mass and dimensions of the damper is necessary to properly choose the size relative to the boring bar while keeping the assumption:

$$\underline{\Omega_{bar} = \Omega_{damper}}$$

$$\Omega_d = \sqrt{\frac{k_d}{m_d}} \quad \Rightarrow \quad k_d = m_d \cdot \Omega_d^2$$

$$k_d = \frac{3EI_4}{\left(l_4 + \frac{l_d}{2}\right)^3} \quad \text{(neglecting the stiffness of the mass damper)}$$

$$\text{Given}: l_4 = 10\ mm \quad ; \quad \text{We choose}: \phi D_d ; l_d ; \rho_d ; E$$

$$m_d \cdot \Omega_d^2 = \frac{3EI_4}{\left(l_4 + \frac{l_d}{2}\right)^3} \quad ; \quad I_4 = \frac{\pi D_4^4}{64} \quad \Rightarrow \quad D_4 = \sqrt[4]{\frac{64}{3\pi} \cdot \frac{m_d \cdot \Omega_d^2}{E} \cdot \left(l_4 + \frac{l_d}{2}\right)^3}$$

$$\text{Range of results is } D_4 = 5 \div 10\ mm$$

Example of task

- Assignment for each student is different and is based on a specified ratio L / D of boring bar (ranging L/D > 8), diameter D of boring bar (ranging ∅D= 30÷60 mm) and revolution (the same for all students, for example n = 150 rpm).

- Elastic modulus E= $2{,}1.10^5$ MPa, density ρ= 7850 $kg.m^{-3}$, length of damper neck l_4= 10 mm