OPTIMAL DESIGN

TRAINING LAB. 4

MULTI-OBJECTIVE OPTIMISATION: ACTIVE SUSPENSION

Let us consider the quarter car vehicle model with an active suspension.

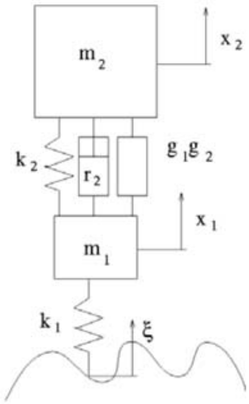

Figure 1 Quarter car vehicle model with active suspension.

The force exerted by the actuator is a function of the relative displacement between wheel and cabin and the absolute velocity of the vehicle body (sky-hook configuration):

$$F_{actuator} = g_1(x_2 - x_1) + g_2\dot{x}_2$$

g_1 expresses an additional stiffness, while g_2 is the damping factor which is the “active” part of the suspension.

For the sake of simplicity we assume k_2 = r_2 = 0.

The parameters of the model are:

- m_1 : unsprung mass
- m_2 : sprung mass
- k_1 : tyre radial stiffness
- k_2 : suspension equivalent stiffness (supposed linear)
- r_2 : suspension equivalent damping (supposed linear)
- g_1 : actuator gain (stiffness)
- g_2 : actuator gain (sky-hook damping)
- ξ_1 : road irregularity

Determine the values of the actuator gains (g_1, g_2) in order to minimize *discomfort* and *road holding* at the same time.

The expressions of the objective functions (with also the Working space) are:

$$\sigma_{\ddot{x}_2} = A \cdot \sqrt{\frac{k_1 g_1}{m_2 g_2}}$$

$$\sigma_{F_z} = A \cdot \sqrt{\frac{g_1 k_1 (m_1 + m_2)^2}{g_2 m_2} - \frac{k_1^2 (2m_1 + m_2)}{g_2} + \frac{k_1^3 m_2}{g_1 g_2} + \frac{g_2 k_1^2 m_1}{g_1 m_2}}$$

$$\sigma_{x_2 - x_1} = A \cdot \sqrt{\frac{k_1 m_2}{g_1 g_2} + \frac{g_2 (m_1 + m_2)}{g_1 m_2}}$$

with

$$A = \sqrt{\frac{A_b v}{2}}$$

Reference values for the parameters are reported in Tab. 1.

Tab. 1 parameters of the problem

Parameters	Value
A_b [m]	1.4e-5
v [m/s]	30
m_2 [kg]	230 (adapt to the chosen vehicle)
m_1 [kg]	30 (adapt to the chosen vehicle)
k_1 [N/m]	120000 (adapt to the chosen vehicle)

The field of variation of the design variables are reported in Tab.2

Tab. 2 field of variation of the design variables

Design variable	Field of variation
g_1	0 ÷ 400000
g_2	0 ÷ 100000

Requests:

- Determine the Pareto-optimal set in the design variables and objective functions domain. Choose one of the methods applied in Lab. 2 and 3.
- Compare the obtained Pareto-optimal set with the one of the passive suspension in the objective functions domain.