Requirements on the design

The machine design must meet several requirements that follow from the design and properties of linear direct drives. For example, the moved masses should be minimized while the rigidity is kept high.

Mass reduction

To achieve high acceleration, the mass of the moved machine elements must be reduced to a minimum. This can be done with materials of low specific weight (e.g. aluminium or composite materials) and with design measures (e.g. skeleton structures).

If no extreme acceleration is required, masses of up to several tons can be moved without problems. There is no control-engineering correlation between the moved slide mass and the motor's mass, as there is with rotary drives. The precondition, therefore, is a very stiff coupling of the motor to the load.

Mechanical rigidity

Together with the mass and the resulting resonant frequency, the rigidity of the individual mechanical components chiefly determines the quality a machine can achieve. The rigidity of a motion axis is determined by the overall mechanical structure. The goal of the construction is to obtain an axis structure that is as compact as possible.

Natural frequencies

The increased loop bandwidth of linear drives requires higher mechanical natural frequencies in the machine structure, in order to avoid exciting vibrations. To ensure adequate control quality, the lowest natural frequency inside the axis should not be less than approximately 200 Hz.

The natural frequencies of axes with masses that do not constantly move (e.g. due to workpieces that must be machined differently) change, so the natural frequency decreases with $f \approx \mathrm{sqrt}(1/m)$ as the mass increases.

Mechanically linked axes

The elasticities of the axes — both the mechanical and the control-engineering components — add up. This must be taken into account when considering the rigidity of kinematically coupled axes. If several axes must be kinematically coupled to produce path motions (e.g. a cross-table or gantry structure), the mutual effects of the individual axes on each other should be minimized. For this reason, kinematic chains should be avoided in machines with several axes. Axis configurations with long projections that change during operation are particularly critical.

Reactive forces

Reactive forces, initiated by the acceleration, deceleration, or process forces of the moved axis, can deform the stationary machine base or cause it to vibrate.

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