Hexapods: Steward Gough Platforms, Insects and Robots by Piezo

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The term hexapod is derived from the Greek word for six-legs and has adapted a variety of different meanings.

Insects & Walking Robots

In the animal kingdom, hexapod describes insects and some other related miniature six-legged groups.

In the mechanical engineering world, hexapod again has two different meanings. There are hexapod positioning platforms and hexapod walking robots, modeled after the way insects move.

Stewart Gough Platforms

Hexapod positioning platforms (also often called Stewart platform or Stewart Gough platform) have had a significant impact on advancing several industries. These positioning platforms are called parallel kinematic machines or direct kinematic robots because all actuators directly operate on one platform in parallel.   Today there are many different hexapod platform designs, but the first one was devised by Eric Gough, an engineer involved in automotive tire testing. He developed the high-load hexapod 6-axis positioning platform to apply loads to his tires in all 6 degrees of freedom i.e. the 3 linear movements (XYZ) and the 3 rotations, around X, Y and Z (also called pitch, roll and yaw).

Hexapods are most widely known from flight simulators and driving simulators, where huge hydraulic actuators provide high forces and fast motion.   Actually, in 1965, a paper published by D. Stewart in the UK described the idea of using a 6-degree of freedom motion platform for flight simulators. This is how the Stewart platform came by its name.

High Precision Hexapod Platforms

On the other end of the spectrum are ultra-high precision hexapod positioners with electro-magnetic and piezo–electric drives for applications such as fiber optic alignment, nanotechnology and computer aided surgery. Here precision down to the sub-micron and even nanometer realm is required. The control of a Hexapod needs a fast processor to provide the necessary coordinate transformations and 6-D vector movements. Typically every move, even a simple straight-line linear motion, involves all 6 actuators. This can be a challenge in the mechanical and controller design.

Serial and Parallel Kinematics

On the other hand, hexapods have many advantages over conventional multi-axis positioning systems (serial kinematics, or stacked axes). Hexapods are lighter in weight, higher in stiffness and lower in inertia that these traditional positioning systems.   The lower inertia allows for much higher dynamics, faster acceleration and start / stop behavior.   Hexapods and parallel-kinematics are even used in CNC precision machining centers and also in pick and place robots due to their fast response.

More Hexapod Applications

Large astronomical telescopes mostly use hexapod positioners to align optics and mirrors. The small footprint , high stiffness and large central aperture play a key role here.   Automated, motorized fiber positioners also benefit from the hexapod principles. With all degrees of freedom, and a freely programmable pivot point, rotations of the fiber tip can be executed around the beam waist, and even fiber bundles can be aligned quickly and efficiently.

In vacuum applications, space is usually at a premium and smaller is better when it comes to installing a positioning system inside a vacuum chamber.   Here, the compact vacuum hexapod design provides further advantages.   Since cables are not attached to the individual sliding and rotating axes such as with stacked positioners, there are no issues with hitting obstacles and no bending forces or torque exerted by the stiff vacuum cables affect the precision of the positioning system negatively.

While hexapod precision positioning systems will not replace all traditional multi-axis positioners any time soon, the variety of options that are available today (mechanical configurations, advanced controllers and software simulation tools to help with the design and installation) will make it easier for motion-system design engineers to think outside of the traditional box / stack.

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