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The design of aircraft landing gear presents a complex challenge, requiring the system to support the aircraft while also absorbing energy during landing and braking, while minimizing mass to reduce drag during flight. According to R. Kyle Schmidt's book "The Design of Aircraft Landing Gear", this involves iterative loops of evaluation and modification, taking into account factors such as airfield compatibility, tire choice, brake systems, and shock absorber designs. The design process also considers the trade-offs between weight reduction and structural integrity. A key consideration is the study of landing gear architectures, including retraction mechanisms, kinematics, and actuation approaches. The book covers various hydraulic and electric services found on aircraft, as well as system elements such as lighting and steering. It also delves into detailed design points, analysis processes, and regulatory requirements. As a landmark work in the industry, "The Design of Aircraft Landing Gear" is essential reading for engineers looking to update their skills and students preparing for a career in the field. Landings require two primary functions: supporting the aircraft on the ground and absorbing landing loads. This post will explore different landing gear systems in use today, examine components used to absorb these loads, and introduce common retraction systems. The design of an aircraft's landing gear is crucial for safe takeoff, landing, and ground operations. Most aircraft use wheels to absorb the impact of landing and support the vehicle on the ground. Some aircraft, such as amphibious planes and light aircraft in snowy regions, use alternative solutions like floats or pontoons. A typical landing gear configuration consists of a main set of wheels and auxiliary wheels. The main wheels are designed to absorb the majority of the landing load, while the auxiliary wheels provide additional support on the ground. The main wheels are usually larger, stronger, and located near the aircraft's center of gravity, whereas the auxiliary gear is positioned to maintain balance and stability. There are two primary types of landing gear configurations: conventional (tailwheel) and tricycle undercarriage. Conventional arrangements feature a small nosewheel located at the tail, which provides good propeller clearance and keeps the forward fuselage away from the landing surface. Tricycle configurations, on the other hand, have a main gear positioned just behind the center of gravity and a forward nosewheel. Tricycle configurations offer several advantages over conventional layouts, including improved visibility over the nose during landing, easier ground operations due to a more level nose, and reduced risk of ground loops. The center of gravity is ahead of the main landing gear in tricycle undercarriages, preventing ground loops. However, this configuration presents difficulties in landing and ground operation. Tandem arrangements, which feature aligned main and auxiliary gear on the same longitudinal axis, are not widely used due to their challenges in landing and ground operations. Some gliders use this configuration, as it is very light and only requires a single main wheel. Fixed and Retractable Landing Gear Configurations Aircraft typically feature either fixed or retractable landing gear, each with its advantages and disadvantages. Tandem configuration aircraft, such as the AV-8B Harrier II, use an outrigger on each wing for additional ground stabilization. Fixed landing gear is simpler and lighter to install, but requires no heavy retraction mechanism or cut-outs in the airframe structure. The Cirrus SR-22, a high-performance fixed-gear aircraft, benefits from streamlined struts and fairings that reduce parasite drag. Landing involves an impact between the wheels and runway, transferring energy into the airframe. Shock-absorption techniques, such as using springs or hydraulic struts, can reduce landing forces and stresses by increasing the time over which deceleration is transferred into the structure. Leaf-type spring struts are commonly used in fixed wing aircraft to absorb initial landing impacts before transferring them to the fuselage. Composite landing gear are becoming more prevalent on newer light sport aircraft. As aircraft speeds increase, so does drag. Retractable undercarriages can provide performance advantages at certain speeds. The shock-absorbing systems used on aircraft landing gear are complex arrangements involving hydraulic fluid and compressed air or nitrogen to absorb impact forces. This type of strut is commonly known as an "air-oil" or "oleo" strut and is found in both main gear and nose landing gear. These struts have a specific design where the upper portion contains the cylinder, which is fixed to the aircraft structure, while the lower portion houses the piston connected to the wheel. The piston's ability to slide in and out of the cylinder allows it to adapt to changing loads on the wheel. The cylinder itself consists of two chambers: the upper chamber is filled with compressed air or nitrogen, and the lower chamber contains hydraulic fluid. An orifice located between these chambers controls the rate at which hydraulic fluid enters the top chamber during compression. This process is regulated by a metering pin that increases in diameter as the piston moves inward, limiting fluid flow and causing pressure to build up within the strut. As this pressure increases, it generates heat through energy dissipation, effectively reducing the impact force transferred into the aircraft structure. Shock struts are often complemented with torque links or arms that prevent the piston from rotating inside the cylinder. These scissor-shaped components allow for the piston's extension and retraction while maintaining wheel alignment necessary for a safe landing. Some aircraft may experience a shimmying effect in their nosewheel, which can compromise directional control during take-off or landing. This issue is often caused by worn oleo or loose torque links and can be addressed with the installation of a shimmy damper. This device consists of a small hydraulic piston and cylinder filled with fluid installed between the oleo cylinder and piston. A bleed hole regulates fluid flow, damping out any vibration in the wheel. Steering mechanisms on light aircraft typically involve a mechanical push-rod system connecting the nosewheel to the rudder pedals, transferring inputs from the rudder to the wheel assembly around its longitudinal axis. In larger airliners, steering is controlled through a hydraulic system and a tiller located in the cockpit rather than the rudder pedals. As an aircraft's cruise speed increases beyond a certain point, gear retraction becomes necessary to minimize drag and enhance overall efficiency. This process involves mechanical linkages that retract the landing gear into the wheel wells or compartments within the fuselage. The landing gear on an airplane needs to be retracted after takeoff due to drag caused by its presence in the slipstream. To achieve this, a mechanism is installed that stows the gear during departure. There are two common types of retraction mechanisms: electric motor-driven and hydraulic power pack-driven. Electric retraction uses an electric motor with geared rotational motion converted to linear motion, suitable for light aircraft with low-mass landing gear legs. Hydraulic retraction involves generating large forces through hydraulic action necessary for extending and retracting heavy multi-wheeled landing gear bogies found on larger planes. Airliners use the main engines' power to drive hydraulic pumps for gear actuation, while smaller planes employ an electric/hydraulic power pack system. In emergencies where the primary extension system fails, aircraft must provide a means for pilots to extend the gear manually or through alternative systems like gravity-driven extension or compressed air on larger planes. The landing gear's position is monitored by an indication system in the cockpit, typically using three lights: green for down and locked, yellow/red for gear in transit, amber/red if one leg doesn't lock properly, and no lights illuminated for correctly stowed gear during flight. Advances in computational technology have made it more feasible to design aircraft and spacecraft crash simulations using explicit, transient dynamic finite element analysis (FEM) codes. In plane crash models, the landing gear's response is approximated by a strong spring with various forces applied to different parts of the fuselage, computed through user-written algorithms. Helicopter crash simulations employing this approach are compared to data from experimental methods and full-scale crash tests on composite aircraft structures. The results also depend on the type of landing gear system used. Nonlinear models can be easily developed and simulated against static and dynamic test data, incorporating effects like high damping, nonlinear spring behavior, and stick-slip friction.