COUPLING SYSTEM FOR A PLANETARY GEAR TRAIN

TECHNICAL FIELD

This invention relates to planetary gear trains and more particularly to a coupling system for flexibly connecting the gear train's sun gear and ring gear to a rotating shaft and a nonrotating mechanical ground respectively so that the reliability and durability of the gear system components are improved. The invention is especially useful in aircraft engines where reliability, durability and simplicity are highly desirable.

BACKGROUND OF THE INVENTION

Planetary gear trains are complex mechanisms for reducing, or occasionally increasing the rotational speed between two rotating shafts or rotors. The compactness of planetary gear trains makes them appealing for use in aircraft engines where space is at a premium.

The forces and torque transferred through a planetary gear train place tremendous stresses on the gear train components, making them susceptible to breakage and wear, even under ideal conditions. In practice, conditions are often less than ideal and place additional stresses on the gear components. For example the longitudinal axes of a planetary gear train's sun gear, planet carrier, and ring gear are ideally coaxial with the longitudinal axis of an external shaft that rotates the sun gear. Such perfect coaxial alignment, however, is rare due to numerous factors including imbalances in rotating hardware, manufacturing imperfections, and transient flexure of shafts and support frames due to aircraft maneuvers. The resulting parallel and angular misalignments impose moments and forces on the gear teeth, the beatings which support the planet gears in their carrier, and the carrier itself. These imposed forces and moments accelerate gear component wear and increase the likelihood that a component will break in service. Component breakage is obviously undesirable in any application, but particularly so in an aircraft engine. Moreover, accelerated component wear necessitates frequent inspections and part replacements which can render the engine and aircraft uneconomical to operate.

The risk of component breakage can be reduced by making the gear train components larger and therefore stronger. Increased size may also reduce wear by distributing the transmitted forces over correspondingly larger surfaces. However increased size offsets the compactness that makes planetary gear trains appealing for use in aircraft engines, and the corresponding weight increase is similarly undesirable. The use of high strength materials and wear resistant coatings can also be beneficial, but escalates the cost of the gear train and therefore does not diminish the desire to reduce wear.

Stresses due to misalignments can also be reduced by the use of flexible couplings to connect the gear train to external devices such as rotating shafts or nonrotating supports. For example, a flexible coupling connecting a sun gear to a drive shaft flexes so that the sun gear remains near its ideal orientation with respect to the mating planet gears even though the axis of the shaft is oblique or displaced with respect to a perfectly aligned orientation. Many prior art couplings, however, contain multiple parts which require lubrication and are themselves susceptible to wear. Prior art couplings may also lack adequate rigidity and strength, with respect to torsion about a longitudinal axis, to be useful in high

torque applications. Misalignment can also be accommodated by a splined connection. However the motion that occurs between the contacting spline teeth in a splined connection creates friction which is highly variable and causes the flexibility of such a connection to also be variable.

In view of these shortcomings a simple, reliable, unlubricated coupling system for connecting components of a planetary gear train to external devices while accommodating misalignment therebetween is sought.

DISCLOSURE OF THE INVENTION

According to the present invention, the sun gear and ring gear housing of a planetary gear train are connected to an external shaft and an external mechanical ground respectively, by unique couplings having undulant cross sections for accommodating parallel and angular misalignments. The coupling system is rigid with respect to torsion about the gear train longitudinal axis but is compliant with respect to torsion about the vertical and lateral axes and with respect to translation along all three axes.

In one detailed embodiment, the sun gear is connected to an external shaft by a sun gear coupling which includes a spindle, a ring with a diameter greater than that of the spindle and connected thereto by longitudinally spaced apart diaphragms. The junctures between the spindle, ting, and diaphragms are curved to improve flexibility of the coupling and minimize stress on the junctures. The ring gear housing is connected to an external ground by a ring gear coupling which includes a central hub connected to an arch located radially outwardly of the hub. The juncture between the arch and the hub is curved to improve flexibility of the coupling and minimize stress concentrations thereon.

The invention may also include a deflection limiter for limiting excessive displacement of the ring gear housing, and an anti-torque spline to resist rotation of the ring gear housing in the event that the ring gear coupling breaks or becomes deformed. The deflection limiter and anti torque spline may be used individually or in combination and the deflection limiter may include a damper for damping vibrations normally encountered during operation.

The primary advantage of the invention is the reduced maintenance cost and improved reliability of the gear train due to reduced wear and reduced risk of breakage of gear train components.

Further advantages of the invention include the simplicity and reliability of the couplings arising from the absence of multiple parts which are susceptible to wear and may require lubrication.

The foregoing and other features and advantages, and the operation of the invention will become more apparent in light of the following description of the best mode for carrying out the invention and the accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a schematic cross sectional side elevation of a turbine engine with a planetary gear train interposed between a compressor and fan employed therein.

FIG. 2 is an upper cross sectional elevation of the planetary gear train of FIG. 1 showing the coupling system of the present invention.