Modeling and Assembly of a Ring Laser Gyroscope

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Abstract: The ring laser gyroscope consists of a ring laser having two independent counter propagating resonant modes over the same path; the difference in the frequencies is used to detect rotation. It works on the principle of sagnac effect, which shifts the nulls of the internal standing wave pattern in response to angular rotation. Modeling of components such as base plate, dither ring, mirror, anode, cathode and sensor block is done and the final assembly of ring laser gyroscope is designed in CATIA software.

Introduction

Navigation is the term used to represent the information required in air, land, space and ocean regarding the position and direction. The navigation systems are used for determining the position, velocity and direction relative to some reference coordinate system. Sensors comprise accelerometers and gyroscopes, commonly abbreviated to gyros. An accelerometer measures specific force and a gyroscope measures angular rate, both without an external reference. Most types of gyros measure angular rate about a single axis. The applications of gyroscopes include inertial navigation system where magnetic compasses would not work or with low precision.

Ring Laser Gyroscope

A Ring Laser Gyroscope is a device used for measuring or maintaining orientation, based on the principles of angular momentum. It typically consists of a rotating wheel mounted so that its axis can turn freely in all directions. Ring laser gyroscopes replace a spinning wheel with laser light traveling around a loop. It consists of a ring laser having two counter-propagating modes over the same path in order to detect rotation. The two lasers travel in opposite directions on a triangular route. When the gyroscope is rotated on its axis, one of the laser beams rotational path is shortened while the other beams' path is lengthened. The difference in time between the two laser beams is its angular change. The navigation of airplanes and ships, alignment of telescopes, survey of landscapes and high precision measurements all require the use of gyroscopes.

Principle of Operation

It operates on the principle of the Sagnac effect which shifts the nulls of the internal standing wave pattern in response to angular rotation. Interference between the counter-propagating beams, observed externally, reflects shifts in that standing wave pattern, and thus rotation. A certain rate of rotation induces a small difference between the time it takes light to traverse the ring in the two directions according to the Sagnac effect. This introduces a tiny separation between the frequencies of the counter-propagating beams, a motion of the standing wave pattern within the ring, and thus a beat pattern when those two beams are interfered outside the ring. Therefore the net shift of that interference pattern follows the rotation of the unit in the plane of the ring.
Components of RLG

The components which build up Ring Laser Gyroscope are base plate horizontal, base plate vertical, dither ring, mirror, anode, cathode and sensor block. Each and every component is manufactured with different material with different mechanical and thermal properties.

4.1 Base Plate

The Base Plate provides support to the sensor block to rest on it. Sensor block doesn't have any direct contact with the base plate. Base plate arrest the vibrations and other disturbances reaching the sensor block which helps in getting accurate results. The material used in building the base plate is Aluminum AA2014.

4.2 Dither Holder and Dither Ring

The Dither holder is used to hold the dither ring firmly. It is made up of Aluminum AA2014. The dithering contains spokes, these spokes help in rotating the dithering which in turn rotates the sensor block. The sensor block is forced rotated with the dithering so as to misalign the laser signal which is moving in the same path but in opposite direction. Dithering does not allow the wave signals of the two standing waves match each other. The number of spokes varies from one sensor block to the other. There will be a change in the shape of the dithering depending about the sensor block shape. The material used is Invar alloy(FeNi42).

4.3 Anode and Cathode

The anode and cathode cathode are used to produce an electric current in the sensor block which is used in running the electronic chips present in the block which helps in determining the angular rates in the form of electronic wave signals.

4.4 Mirror

Mirrors are used to reflect the laser beam from one face to the other which helps the laser beam to travel in the laser cavity. Along with the anode and cathode, the mirrors are also placed on the sensor block were as the remaining components are arranged outside the sensor block.

4.5 Tri-Axial Sensor Block

The sensor block is made up of rhombic shape which contains three planar laser ring cavities. Each of such cavities is arranged to detect rotation about one of three orthogonal axes. Each comprises four straight equal cavity segments of equal length. A planar section of the three dimensional discloses a planar ring cavity that includes four corner mirrors. The rhombic shaped frame is such that the light incident angle for the mirrors of each of the three intersecting cavities is approximately 36 degrees. Zerodur is the material used for manufacturing the sensor block.

Applications of RLG

The application of Ring Laser Gyroscope are as follows:

- Airbus A 320
- Agni III
- Boeing 777
- F-16
- HAL-Tejas
- Shaurya Missile
- Sukhoi Su-30MKI
- SH 60F, SH 60B Sea Hawk Helicopters

Design Specifications

The design specifications of Ring Laser Gyroscope is shown in the below figure 3.

![Figure 3.1. Design Specifications](image1.png)

![Figure 3.2. Design Specifications of Sensor Block](image2.png)
Modeling of RLG Components in CATIA V5R18

Modeling of components of Ring Laser Gyroscope are modeled in CATIA software with required dimensions as shown in below figures

Model of Base Plate is as shown in figure 4.1

Figure 4.1 Model of Base Plate

Model of Dither Holder is as shown in figure 4.2

Figure 4.2 Model of Dither Holder

Model of Dither Ring is as shown in figure 4.3

Figure 4.3 Model of Dither Ring

Model of Cathode is as shown in figure 4.4

Figure 4.4 Model of Cathode

Model of Anode is as shown in figure 4.5

Figure 4.5 Model of Anode

Model of Mirror is as shown in figure 4.6

Figure 4.6 Model of Mirror

Model of Tri-Axial Sensor block is as shown in figures 4.7.1 and 4.7.2

Figure 4.7.1 Model of Tri-Axial Sensor Block
Assembly of RLG Components

The Assembly of anodes, cathodes, and mirrors are done to the sensor block in the prior step which is as shown in below figure 4.8.

The Assembly of base plate, dither holder and dither rings is done as shown in figure 4.9.

1. Limitations of RLG

The limitation of RLG is that rotation sensing is due to its Lock-in-Effect. At low rotation rates, difference in frequency between two light beams causes injection locking.

References


