Development of Piezo Reaction Equipment for Cubesat Type Satellites

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INTRODUCTION

Reaction wheels by now are the most precise mean of attitude control of the satellite.

Reaction wheels are mechanically quite complex;

To ensure reliable attitude control around 3 rotation axis 3 reaction wheels are necessary;

Nonetheless reaction wheels are irreplaceable for remote sensing satellites.
Piezo reaction equipment

Kaunas University of technology was one of the first institutions in the world to work in piezo gears.

Implementation of piezo gears allow rapidly decrease mass, size, complexity of the gear while increasing the possible acceleration.

Several types of single axis piezo gears have been developed by KTU/SSTI.
Implementation of sphere on stead of wheels allows implementation of single reaction sphere instead of 3 reaction wheels;

Electro-magnetic reaction sphere was constructed by CSEM (Switzerland) several years ago. The device is large and bulky;

The principle of 3 axis rotation of sphere by the piezo gear was known for long time.

Implementation of piezo gears for reaction sphere allows decreasing the mass and complexity of the instrument considerably,
The steel sphere can be rotated via 3 axis using:

1. Cylindrical shape piezo ceramics, divided into 3 symmetrical sections;
2. Special hemispheric shape ceramics transducer
The reaction sphere could be held in place using:

1. Constant magnets;

2. Any other external force producing the tension between the sphere and piezo element (intermediate element).
Advantages of piezo reaction sphere:
• Small size of the gear;
• Lack of mechanical parts;
• Rapid reaction of the gear ensuring rapid attitude control;
• Low price of equipment.

Piezoelectric attitude control equipment has some serious drawbacks:
• High energy consumptions (to be determined);
• Lack of the feedback on the sphere rotation;
• Wear of contact areas sphere – contacting elements, fixed to the piezoelectric transducer.
1U CUBESAT

- 1U, 1 kg CubeSat;
- Required torque compensation 8 deg/s;
- Total momentum of inertia of satellite $1.67 \times 10^{-3}$ kg·m²;
- Required torque of $2.33 \times 10^{-4}$ Nm;
- Stainless steel sphere of 25 mm diameter rotating up to 500 min⁻¹ (8.3 s⁻¹).
1U CUBESAT
LAYOUT OF SATELLITE

- Reaction sphere
- batteries
- GomSpace NanoCam
- GomSpace ADCS
- GomSpace UHF
- GomSpace EPS
- Pumpkin structure
- Reaction sphere CU

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The equipment for precise attitude control of small satellites is proposed, ensuring accurate orientation at extremely low price, small dimensions and high reliability. Due to unexplored nature of implementation of piezoactuators with several degrees-of-freedom in space environment, further research must be performed to determine the suitability of implementation of piezoelectric devices, described above.
THANK YOU FOR YOUR ATTENTION!