A Review Paper on Rotational Energy Harnessing from a Non-Fixed Axis System

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Abstract: Rotational Energy Harnessing from a Non Fixed Axis System(REHNFA) is a device consisting of Yo-Yo mechanism. In this mechanism a rotor is punched two holes and two strings of elastic material is passed through in it. By applying little starting rotation to the rotor by oscillating the strings it continues its rotation for a long span and that rotation can be harnessed to energy generation/utilization. This study has been undertaken to investigate the research papers of Yo-Yo De-spin Mechanism which is mostly used to reduce the spin of satellites, typically soon after launch. De-spin mechanism is similar to the Yo-Yo mechanism with a difference in the positions of rotor, weights and axis.

Key Words: Yo-Yo, De-spin, Harnessing, Non-fixed axis

I. Introduction

In recent years, energy replenishing is taking its own importance worldwide, because of exhausting of fossil fuels, pollution occurred by conventional power sources and indigenous nature of crude oils. REHNFA can be implemented in any mechanical device which is wasting energy in rotational form like a flywheel does. It is a simple and eco-friendly mechanism. In the arrangement of this mechanism consist: a yo-yo rotor, strings of silicon carbon, levers, cam & follower. Whereas Yo-Yo De-spin mechanism is consists of two lengths of cable with weights on the end. The cables are wrapped around the satellite, in the manner of a double yo-yo. When the weights are released, the spin of the axis flings them away from the spin axis. This transfers enough angular momentum to the weights to reduce the spin of the satellite to the desired value. Subsequently, the weights are often released.

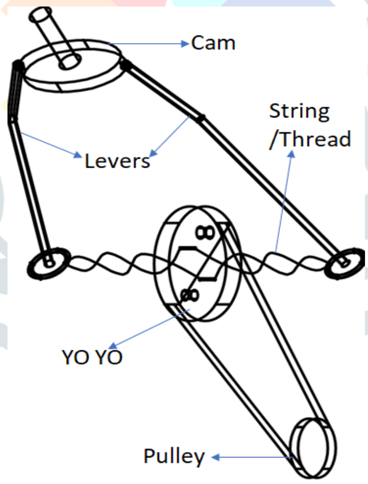

Fig 1: 3D diagram of REHNFA

II. Literature Review

J V Fedor Et al. (1961) [1] derived the simplified equations, greatly facilitate the application of de-spin mechanism theory to a particular design. With the calculation sheet, the procedure has been reduced to reading a graph and making a few routine calculations. There were two phases to the spin process considered. In phase 1 the wire is changing in length and is tangent to the satellite. In phase 2 the length of the wire is constant but its position is changing from tangent to perpendicular to the satellite. It should be noted that releasing the wires after phase 2 is more efficient, weight-wise, than releasing them after phase 1.

Eric J Hoffman Et al. (1992) [2] contributed his work in spacecraft design innovations in the APL space department. Operating in space provided a mechanical engineer's dream: a weightless, frictionless environment in which small torques could perform useful tasks. It is no coincidence that so many of the earliest innovations came in the field of attitude control. In addition, Transit was one of the first programs scheduled for long-term operational use. The need for long-lived satellites led us to reject expendable fuels and moving parts and to seek out passive methods that took advantage of Transit's natural environment at an altitude of 1100 km. This led directly to the development of gravity-gradient and magnetic stabilization.

(a) (b)

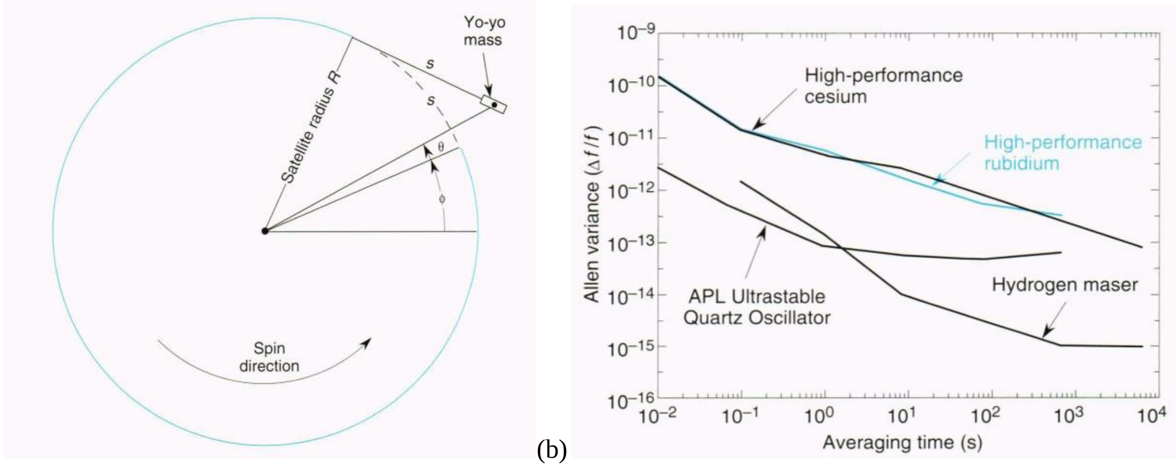

Fig 2 (a) Yo Yo geometry in satellite application
(b) frequency stability of a modern APL satellite oscillator in terms of Allen variance vs Avg time

William R Mentzer Et al. (1963) [3] analyzed the dynamic tests of the stretch yo-yo de-spin system. Results of the stretch yo-yo feasibility and flight qualification tests are presented. These tests were conducted to prove the concept that the stretch yo-yo is more accurate de-spin device than the rigid yo-yo, and to verify the analytical development of the stretch yo-yo properties. Variations in the design parameters and their effects on the final spin rate of the payload are noted in the analysis of the test results. The variables include initial spin rate, moment of inertia, and spinning properties. A computer solution of the test payload equations of motion is included for comparison with the experimental results to confirm the mathematical analysis of the stretch yo-yo system. As a result of the successful flight qualification tests a stretch yo-yo was flown on Ariel 1 (1962) in April 1962.

Kenneth S Bush Et al. (1967) [4] demonstrated that a stretch yo-yo de-spin system is adaptive to spacecraft de-spin applications which require a system to be self corrective in providing a low percentage error in the final de-spin rate with a high percentage error in the initial spin rate. The capability of the system to afford a low error final spin rate is not affected drastically by in-flight variations in the predicted spacecraft roll moment of inertia. Two flight missions of the scanner spacecraft were flown, and in both cases the de-spin system operated within the design tolerances.

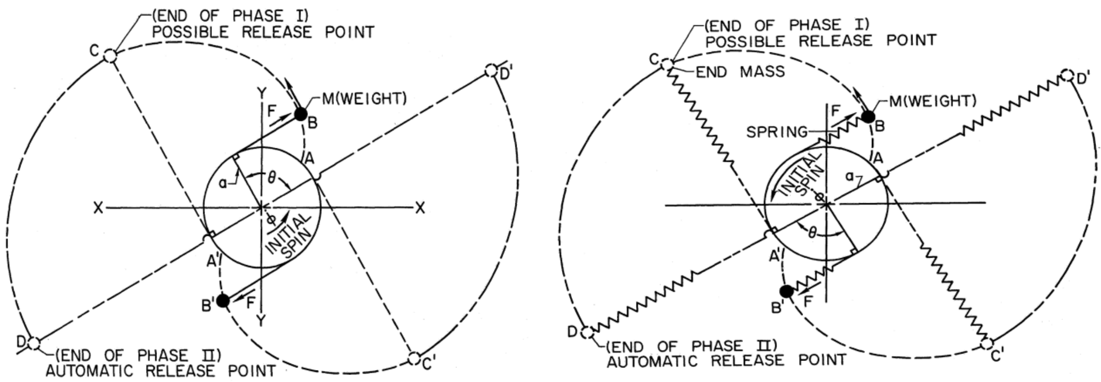

Fig 3 Yo-Yo operation without stretch and with stretch

Vadim Yudintsev Et al. (2017) [5] main contribution of this note is the scheme for space debris using a yo-yo mechanism installed on the ADM module. The scheme can be used for space debris that rotates around the axis of symmetry with high angular velocity. The modified yo-yo mechanism does not contribute to the space debris problem. Each mass of the mechanism consists of two separable dome-shaped shells filled with liquid. Instead of releasing the masses after despin, the liquid is released from the shell. Wire guides for the reel are proposed, which follow the motion of the wires and prevent coming off the wires from the reel due to the attitude motion of the debris. The rotation of the debris around the transverse axes also can be eliminated without using thruster taking advantage of the tether connecting the tug with the ADM module. In this case, the design of the ADM module can be simplified.

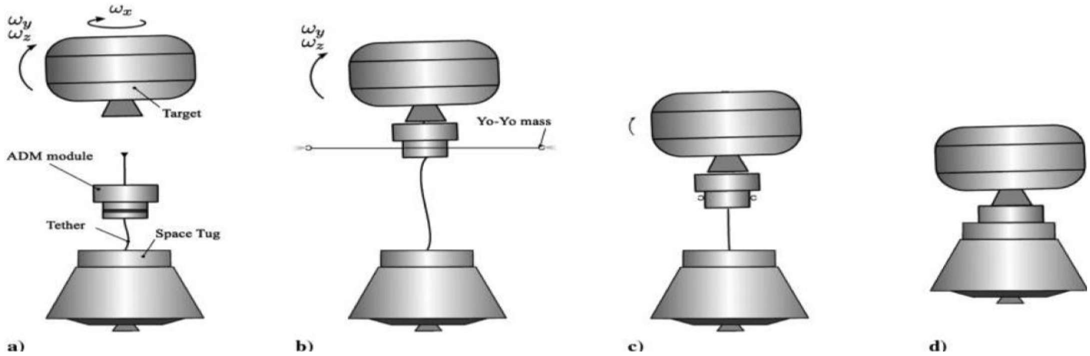

Fig 4 Stages of the ADR using ADR module: a) separation of the module, b) docking with the target and despin, c) retraction the tether and detumbling and d) docking with the tug.

Mark L Psiaki Et al. (1999) [6] developed a wire boom deployment system which uses a mechanism similar to classic yo-yo de-spin mechanism. The goal has been to develop a way to rapidly deploy wire booms from a spinning sounding-rocket experiment. The main challenge in using a yo-yo type mechanism is to dissipate the excess kinetic energy so that the wire booms do not re-wrap themselves about the spacecraft after deploying. A ring has been added to the basic yo-yo mechanism. It rotates with respect to the main spacecraft about the nominal spin axis, and the wire booms deploy from it. The ring/spacecraft joint is damped, and relative motion between the ring and the spacecraft dissipates the excess energy. Techniques are developed for turning the damping law to rapidly deploy the wire booms without the occurrence of re-wrapping, and a criterion is presented that ensures 3D stability of the final equilibrium in the global minimum energy sense.

Mark L Psiaki Et al. (2005) [7] developed a new yo-yo type wire boom deployment system has been developed and flown on a sounding rocket mission. This system allows wire boom to be deployed from a spinning spacecraft in a matter of seconds. One critical element of a practical system is a semi-active magnetorheologcical brake, which provides the energy dissipation that is needed in order to prevent re-wrapping of the booms after they have reached their full extensions. Another key development has been an ability to design a system that has significant axial offsets between the spacecraft center of mass, the boom base attachment points, and the stowed positions of the boom tip masses. Such offsets allow one to design a relatively simple deployment mechanism, but they force the system to tolerate a slightly unstable nutation mode. This slight instability can be restricted to manageable levels for a sounding rocket mission through the use of wire booms that exhibit low damping of their pendulum motion.

Jorge Roberto Wolf Et al. (2006) [8] studied the issues related to a de-spin (yo-yo) system to reduce angular velocity (spin) of an in-orbit rocket or satellite right after launch is presented in this article. Requirements related to the launch vehicle design, operational aspects of the launching campaign, inherent characteristics of the yo-yo system, fabrication of the yo-yo system and field testing are addressed. Solutions are proposed for the several items such as the structure of the rotating body to accommodate the yo-yo system, deployment of concentrated masses that effectively reduce spin, external wire release, adjustment of wire lengths, cutting device and materials selection. Comments on testing procedures are given based on the characteristics of design and fabrication of the de-spin system proposed.

III. Conclusion

It can be concluded that the yo-yo de-spin mechanism serves several purposes in aerospace spacecraft. After launching the rocket there may be chances of the rocket to get distracted from its desired path due to unbalanced masses, different engine thrust direction and intensities. There may be aerodynamic wind force may affect the rocket and drag it to undesired path. This mechanism also tend the rocket satellite to come to the stable state from spinning, as in the space there is no retardation motion for the spin of the rocket and hence it continues rotating until some other external source is applied. Yo-yo de-spin system takes care of all of the above problems efficiently and effectively. In here, the spin axis is fixed, but in REHNFA system the rotation of masses are not bound to any axis, thus power can be easily transmitted without any shaft loads.

IV. References

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