Seminar

Institute for Plasma Research

Title : Design and Development of Gravity Compensated Remote Handling Arm

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Venue : Online - Join the talk:
https://meet.ipr.res.in/MScDefence_Committee01_ManoahStephenM

Abstract :

Tokamak inspection and failed in-vessel components replacements requires long reach multi-Degree of Freedom (DOF) remote handling (RH) articulated arms mounted with viewing and manipulation tooling. Mostly maintenance and inspection RH systems are designed as cantilevered structures to maneuver the torus, due to the limitation of providing additional structural support inside the tokamak during its operation. Due to long cantilevered length and payload handling, serial kinematic chain arms propagates increasing forces back through the mechanism; half of the actuator torque at base joint is consumed to work against these gravity effects. Strong reduction of size and weight is required to successfully achieve the design and functional requirements of articulated robotic arm.

The aim of the project is to develop gravity compensated articulating 3-DOF robotic systems. In passive gravity compensation system employing zero-free length spring, the strain energy in the spring elements, which is used to counter the gravitational potential. The robot mass and payload are the main causes of gravity torques, but most of this torques is generated by the robot mass rather than the payload. As the robot mass is greater than the mass of the payload. It is therefore clear that counterbalancing the gravitational torque due to the robot mass can minimize the torque required at each joint.

A methodology for the conceptualization of a gravity compensated serial articulated arm is arrived in this work. In design, the articulated arm mass can be completely compensated at any configuration. This will further reduce the load on actuators and gearboxes components, as they need to articulate only the payload while the gravitational load of the system is compensated by the counterbalance mechanism. This project describes a method to passively counterbalance gravity loading at pitching joint for various concepts. Concept-A employs cables, sheaved pins, and extension springs and Concept-B uses cables, multi-looping pulley, and compression springs to counterbalance the link mass and payload. Brief discussion about the estimation of spring stiffness for n-link articulated arm using constant potential energy method. Dynamic Simulation were carried out to determine the spring rates, joint loads and to verify the expected mechanism behaviour for both the concepts. Prototype development for the proof of concept and errors associated with practical implementation are discussed in this work.