Passive Gravity Compensation (PGC) of serial link manipulators for Remote Handling (RH) application

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Abstract

In the maintenance of future tokamak fusion machine, remote inspection of the in-vessel components, first wall and diagnostics systems has been identified as the major challenge. A methodology for the conceptualization of a gravity compensated serial articulated arm is arrived in this paper. In design, mass of the articulated arm can be fully counterbalanced at any configuration. This will further reduce the load on actuators and gearboxes components, as they need to articulate only the payload while the inertial load of the system is compensated by the counterbalance mechanism. This will be achieved using tension or compression springs, wires and sheaved pins (pulleys) or auxiliary linkages (gear, cam and follower); this counterbalance mechanism is suitable to provide passive gravity compensation for all positions of an articulated robotic arm within the specified range of motion.

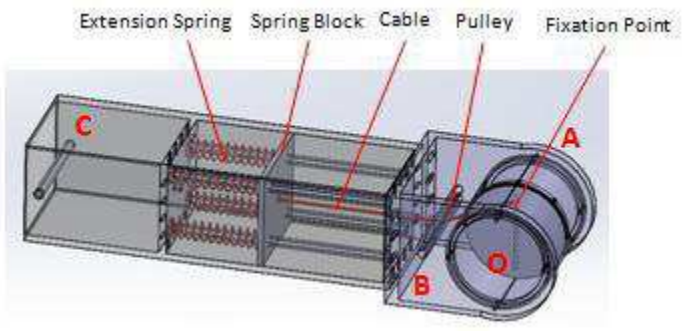

Figure 1: Schematic of gravity compensation mechanism

The 3D CAD model of the prototype is shown in Fig. 01. The prototype structure is made of Aluminium. Pulleys, stopper pins and guide rods are made from Brass and Cylinder about which the link rotates is made of Stainless Steel. Various parameters for the 1-DOF gravity compensation mechanism are listed in Table 01.

Table 01: Selected Parameters for 01-DOF Counterbalance Arm Prototyping

Design Parameters	Value
Mass of arm & payload (m) (kg)	4.5
Length of arm (s) (m)	0.50
Distance between point B to point O (a) (m)	0.035
Distance between point A to point O (r) (m)	0.083
Initial tension length of the spring (r-a) (m)	0.05

Integrated prototype model is shown in Fig. 02. It is designed as a modular unit. Modular design facilitates ease of assembly and replacement of springs with different spring constant is possible, if the end-effector payload has been changed. Linear bushings are used for the reduction of friction between the cylindrical guide rod and the spring block. The cables fixation point can be tuned by relocation of attachment pins on the already existing holes at fixed interval of the circular plate.

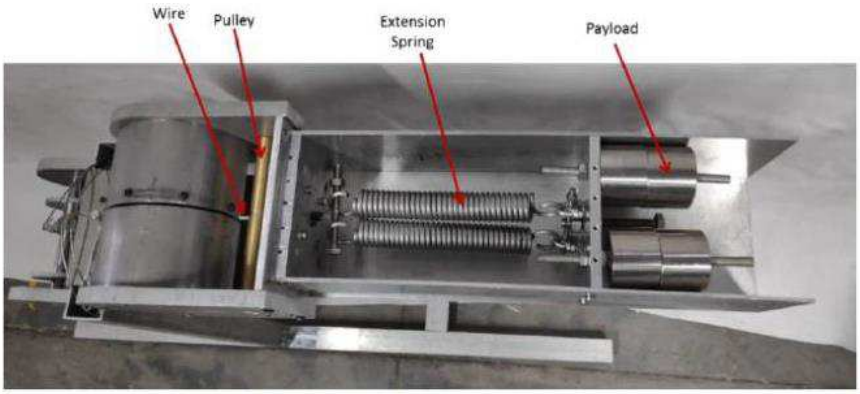

Figure 2: Prototype of passive gravity compensator

Fig. 03(a) shows the travel range of the prototype. Fig. 03(b-d) indicates that the prototype can holds its potion at any configuration. Practically, such a mechanism can be moved by minimal actuation force to any angle and statically holds its position at different angles.

According to the precursory experiments performed, gravitational balancing has been achieved, at each configuration for the travel range of the prototype model as shown in Fig. 03.

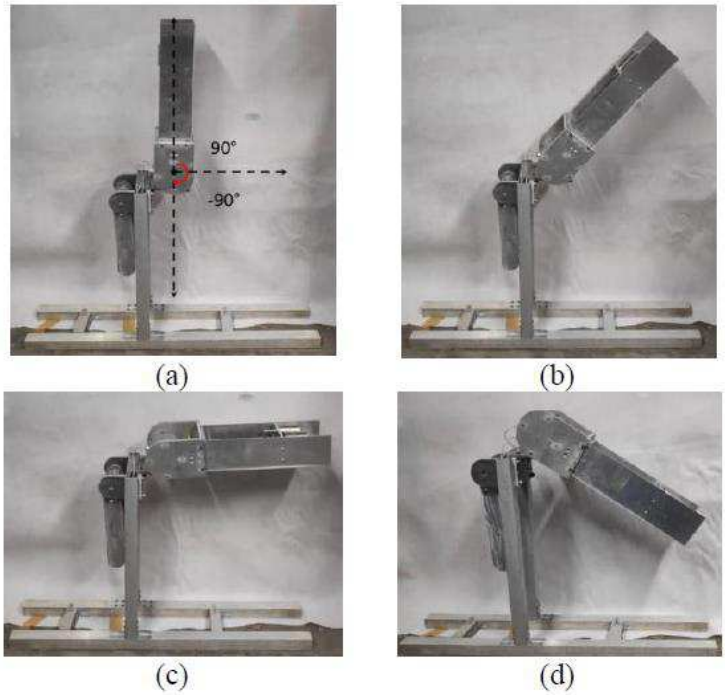

Figure 3: Gravity balancing of the prototype: a range of motion; b–d at different configurations

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