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Modified Canadarm End Effector for Space Shuttle/Payload Maneuvering with OBSS

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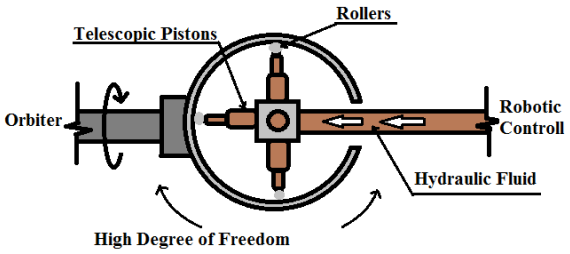
Abstract
Deploying orbiters/payloads in space stations with micro gravity are a major challenge faced by space agencies. Currently used methods used for safe gripping of payloads uses a mechanical robotic arm with multiple degree of freedom. This arm is called *Canadarm*, but it lacks maneuverability over safety. Major challenges faced are harsh surrounding and rare choice of materials sustaining high stresses. Design limitations upon these materials are another set of challenge, which restrict the degree of freedom of orbiters connected with *Canadarm.* Proposed model is a modified *End Effector* for currently adopted Canadarm with OBSS (Orbiter Boom Sensor System) installed for thermal loss inspection of the orbiters. This end effector consist of spherical type key locking system with rollers as in-contacts for a high maneuverability over currently adopted cable gripping system.

Keywords: Canadarm, Orbiter Boom Sensor System, Hydraulic-Robotic Arm, Telescopic Pistons

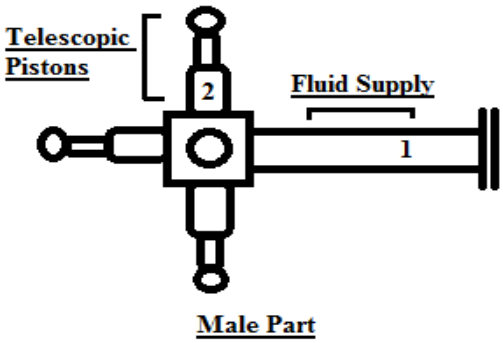
1. Introduction

To grip objects in space the most widely used robot is called as the Canadarm which grips objects like space shuttle, satellites etc. by using a mechanism similar to camera shutter, as the arm comes in proximity of the gripping object it tries to go inside a rod with a circular disc head by computerized or manual input and closes it shutter like gripper to lock the object. The proposed model can be used to grip objects in micro gravity condition. It consists of an end effector the gripper which is the male part attached to the robotic arm and a female part on the object to be gripped.



End Effector Mechanism

2. Design Specifications



Male Part

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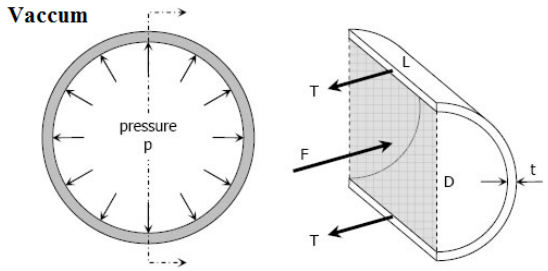
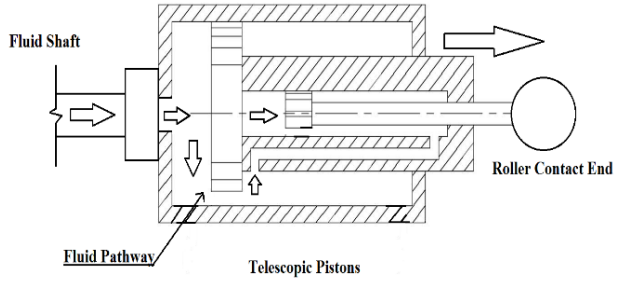
The pressure is a function of the exposure conditions provided to the arm, can be synchronized with OBSS system for precise feed for exposure conditions and control of fluid pressure under shaft. The material specifications can be obtained by testing hoop pressure limiting conditions for space alloys, assuming hollow shaft as thin shell.



p- Fluid Pressure.
T- Hoop Tension.
D- Shaft Diameter.
t- Shaft Thickness.

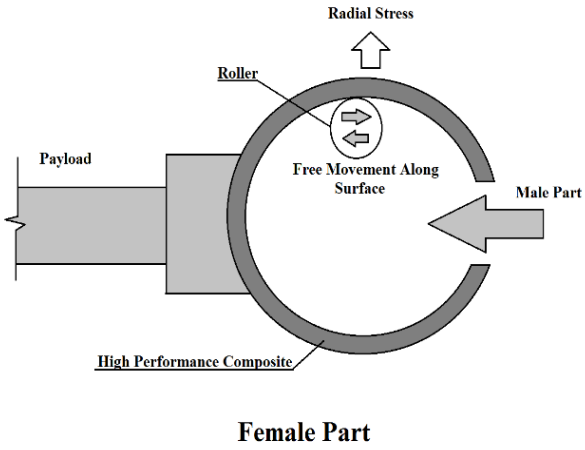
2.1.2 Telescopic Pistons



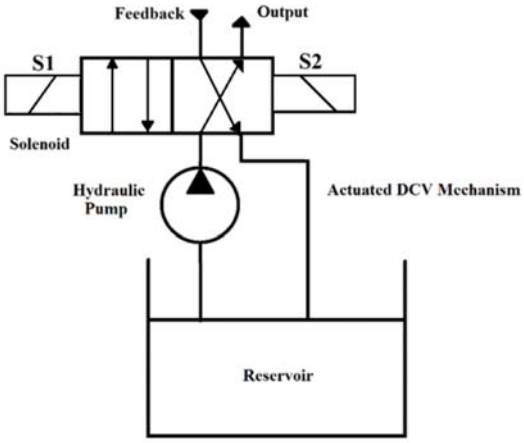
Telescopic pistons with extendable length properties are utilized to make end contact inside female part of the end effector. The rollers with bearing are installed at the end of each telescopic piston to provide high degree of freedom by allowing object to roll around full 360 degrees.

2.2 Female Part

It is a hollow spherical cavity type female joint that is connected to the orbiter/payload. Currently adopted female part contains wires with triaxle arrangements to wind and grip to the rod shaped male part. This method restricts the movement and sometimes expels the object outside. Proposed model for female part contains smooth spherical surface to provide rollers a space for a free movement. The movement of female part can be controlled by supporting movement arms with servo controls.

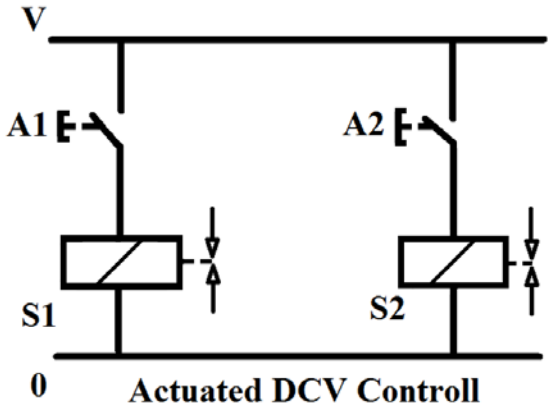


3. Working Mechanism



The above representation is of Solenoid Actuated DCV system that controls the fluid supply to the male end effecter part. The full cyclic flow of the fluid is shown with feedback coming to the reservoir. Actuation control can be controlled by the solenoidal actuated DCV circuit that consists of switch mechanism to the solenoid for forward and backward operations.

4. Actuator Circuit



A1- Actuated Switch 1
A2- Actuated Switch 2
S1- Solenoid 1
S2- Solenoid 2

5. Stress Limitations

5.1 Hoop Stress

Hoop stress develops in thin shells due to high pressure difference between the fluid running inside and outside environment. As outer space is purely vacuum, so a slight increase in fluid pressure can leads to high hoop pressure and can lead to failure of shaft. To avoid such catastrophe, proper design of shaft needs to be done with consideration of hoop tension and circumferential stresses.

hoop stress < hoop (lim)

$$\mathbf{H}t < \mathbf{H}t(\lim)$$

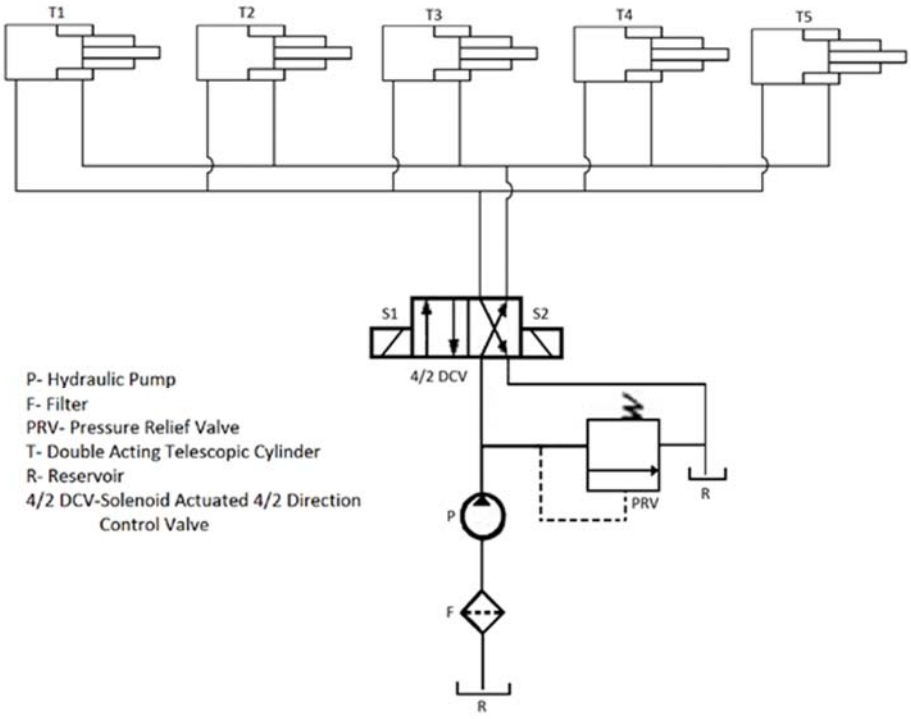
$$\mathbf{H}t = \frac{PD}{2t}$$

P- Fluid pressure
Ht- Hoop stress
t- Shaft thickness
D- Shaft Inner Diameter
Ht **(lim)-** Limiting Hoop stress

P= F (T, M)

Pressure in the shaft is a function of exposure temperature and bending moment needed for controlled movement. “M” can be described as the *rotational inertia* of the payload.

6. Actuation Mechanism



Hydraulic Telescopic Cylinder Parallel Sequence Circuit

The above representation is full actuation circuit with its integration with the actuated components. All the five telescopic cylinders are connected in parallel for extension and retraction operations together. As the solenoid S1 impulse a signal to actuate the DCV, the direction of flow of hydraulic fluid changes i.e. the hydraulic fluid is pumped into the all five telescopic cylinder. The telescopic cylinders are actuated simultaneously together.

For retracting back the telescopic cylinders the solenoid S2 impulse a signal which actuates the DCV and the flow direction changes, the hydraulic fluid pumps out of the cylinders and they retract back to their original position.

7. Acknowledgment

I wish to thank my mentors and college for supporting me in completing my work on *modified end effecter of Canadarm.* I also wish to thank my parents for providing me with assets that helped me completing research regarding this concept.

8. References

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