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USING SMART MATERIALS FOR EFFICIENT AND SAFER FUTURE SPACE MISSIONS

Abstract

When a rocket is launched it has to attain a very high velocity in order to escape the earth's gravity. Rockets go through different regimes of velocities i.e. subsonic, transonic, supersonic and sometime hypersonic and high- hypersonic velocities. Even some space vehicles have to re-enter the atmosphere at Mach number above 25 and land at very low subsonic speeds. For different regimes we have different design characteristics like in subsonic regime vehicle's nose and leading edges are round, in transonic regime vehicle's wings should be swept to delay drag divergence and vehicle to adhere the principles of Whitcomb, in supersonic speeds we see large difference in aerodynamic design because of radical difference between flows above 1 Mach like sharp edges and thin airfoil sections, in hypersonic and high hypersonic speed we see small wings and blunt configurations whereas in reentry speed we prefer ablative heat shield, small or no wing and blunt shape.

But generally the shape of entire vehicle (launched or re-entry vehicle) remains same through the different speed regimes this causes various aerodynamic instability and problems. These problems can be resolved by using smart material. The smart materials that can be used for this purpose are shape memory alloy (SMA) and piezoelectric smart material. Shape memory alloys are materials in which large deformation can be induced and recovered through temperature changes or stress changes (pseudo elasticity). The large deformation results due to martensitic phase change. The piezoelectric material is a smart material which has a fast electro-mechanical response. The piezoelectric material causes piezoelectric effect which is generation of electricity polarization in a material due to mechanical stress. Also, piezoelectric material can me mechanical deformed by passing an electric charge. Because the reaction time is very less for piezoelectric material we can use it over the structure in order to overcome the shape problems. We could use piezoelectric with ceramic material in order to withstand the heat. Due to its dual property we can also use it for sensor to sense if there is any collision or deformation (like from space debris) as well as for actuator for shape control.

Using the combination of piezoelectric smart material and shape memory alloys (SMA) over the structural surface will help us to monitor and change the shape design of the vehicle. This will help us in making future space missions safer and efficient.