AMALGAM 2018

Industry Defined Problem

Problem Statement

Solenoid valves are used for fluid control applications in liquid rocket engines & satellite thrusters for the control of propellant flow and control fluids (those used for actuation of valves with hydraulic/pneumatic circuits).

Presently solenoid valves have design limitation in the area of maximum flux density (B_g) of the materials generally used for this application. This restricts the optimization of size & weight of these valves. The valve operating pressure & port size determines the opening force required for the solenoid actuator. The force is obtained from the solenoid actuator. The force obtained from the plunger depends on the effective attracting area and flux density which the material can provide,

$$F = (B_g^2 * A_p)/2g\mu_0 \tag{1}$$

A_p - Area of plunger, B_g - Air gap flux density, μ_0 - Permeability of air.

If allowable flux density is less, even if the number of turns are increased, flux saturation occurs which limits the opening force. This in turn forces the area to increase, thereby increasing the size/weight of the valve. Currently used material for solenoid valves are AISI 430/446 stainless steels, for which maximum flux density is 0.8 Wb/m^2.

If a stainless steel with flux density more than 3 Wb/m^2 can be used, the weight of the valve can be reduced to $1/3^{rd}$ of the present weight. Hence the core of the problem is either finding out a new material with above mentioned magnetic properties or exploring the feasibility for improving the flux density of currently used materials by modifying the texture.