Structural Analysis of a Pressure Sensor for High Temperature Enviroments

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Introduction: Important sectors of aerospace, automobile and energy industries require sensors that can provide reliable measurements in high temperature environments. Pressure Sensors operating at the temperature higher that 500 C are absent in the world market. Our goal is to develop a pressure sensor that can operate at the high temperature up to 700 C.

Computational Methods: Our sensor will be made up of a ceramic sensible element and a metallic case. The sensible element will be a ceramic beam with a Weathstone bridge on its surface. The gas, entering the lower part of the sensor will warp a plate with thickness 0.5 mm, pushing a pole. The end of the sensible element, with an end fastened to the top of the pole, will undergo an s-shape bending.

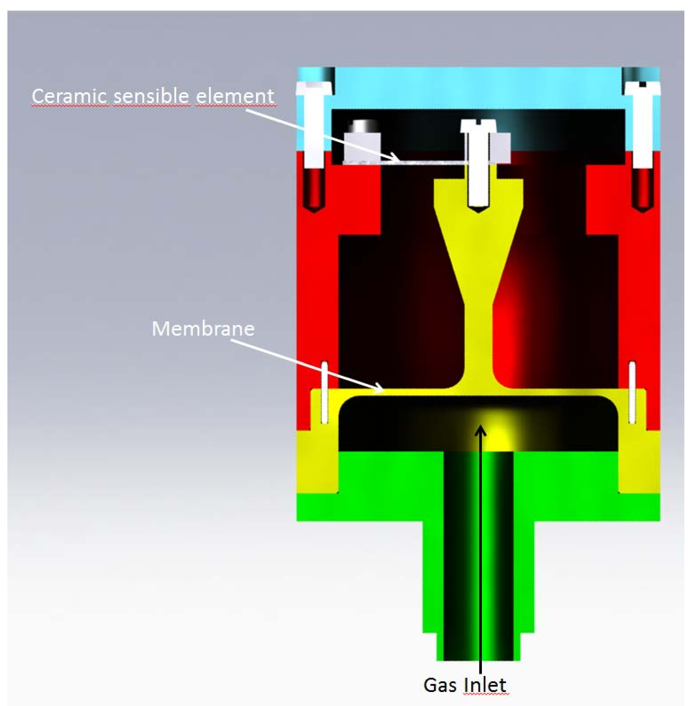

Figure 1. CAD representatio of section of the sensor design

A structural analysis on the case has been performed to design the case and to study the behavior with pressure and temperature of Steel 316L, Inconel 718 and Ti6Al4V; largely used in aeronautics. This analysis was performed using a model reckoning with the mechanical stress due the pressure combined with the thermal expansion of the material. In particular the displacement of the top of the pole and the stress on the membrane were investigated. The results of the stress were compared to the Yield Strength [1, 2, 3] of the considered alloys in order to calculate the Factor of Safety.

Results The displacement grows linearly with the pressure at any temperature with similar rates. But the stresses on the plate grows with pressure and with temperature.

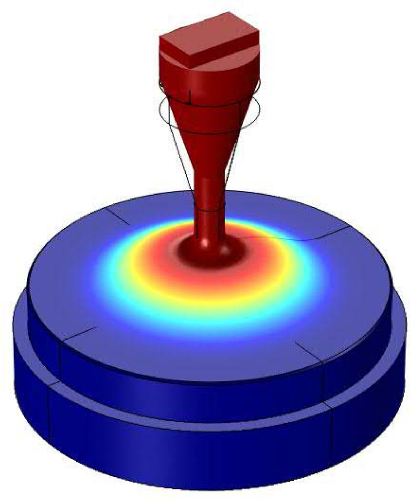

Figure 2. Comsol simulation of piston deformation for a pressure of 4 bbar

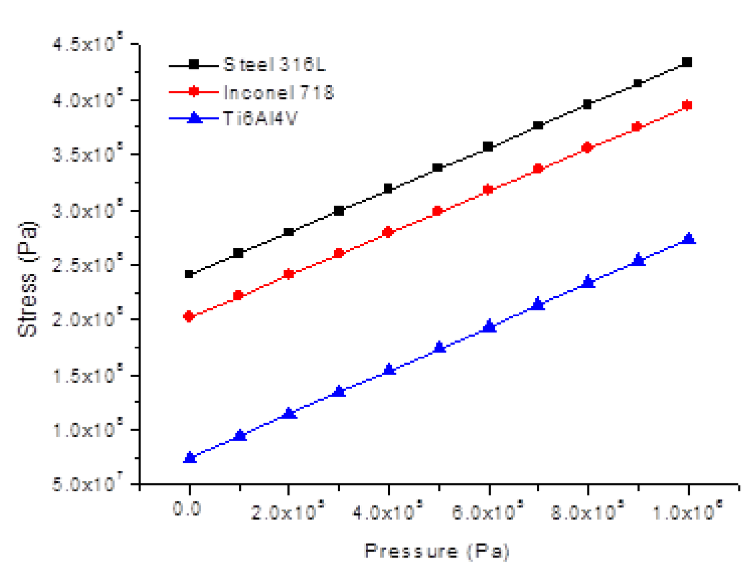

Figure 3. Stress vs Pressure at T=700 C

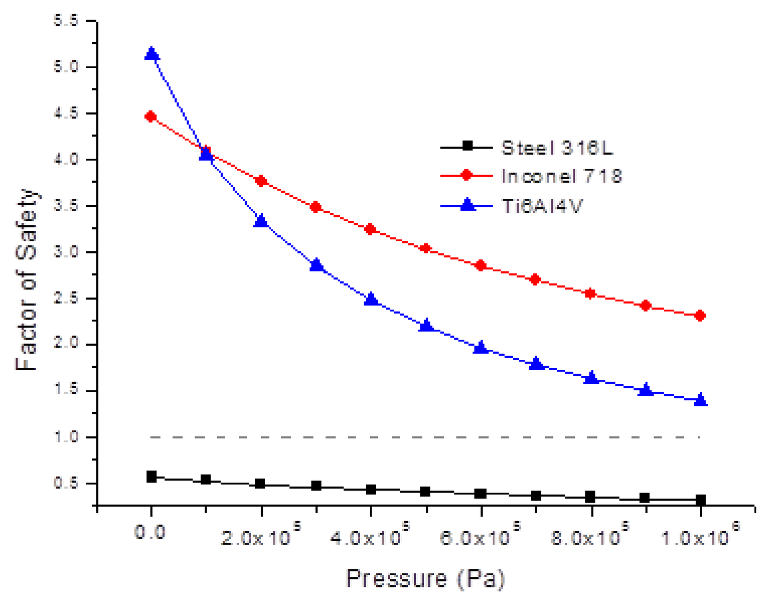

Figure 4. FoS vs Pressur at T=700 C

Conclusion: At high temperature the FoS of the steel is lower than 1, even with a pressure of 0 Pa; because of its low value of yield strength, the mechanical stress due to thermal expansion is over the elastic limit. The Nickel and Titanium alloys have both good behavior. The Inconel has higher FoS values even at high pressure, but the Ti6Al4V exhibits larger values of displacement with growing pressures and then could be useful for a higher sensitivity of the sensor.

References:

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