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Excitation of combustion oscillations by canalization lines containing two different fluids

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Abstract

The presence of stratified columns of two different fluids in a canalization line was predicted to significantly change the characteristic frequency of the canalization. The multiple wave reflections at the interface of the two fluids and the equivalent increase in the path length of the wave motion were seen to give rise to lower frequencies. A canalization tube comprising of gaseous helium and oxygen, when applied for liquid oxygen pressure measurement in the feed manifold, led to the excitation of low frequency limit cycle pressure oscillations in the combustion chamber. The results of the experimental measurements are discussed.

Keywords: Canalization; Frequencies; Stratified fluids; Pressure measurement

1. Introduction

The evaluation of performance of combustion systems calls for measurement of flow rates, pressures and temperatures. The sensors, used for the measurements, often need to be protected from the adverse operating conditions such as very low or high temperatures of the fuel and oxygen supplied to the combustion chamber, the high temperatures of the combustion products and the explosive or corrosive medium for which the sensor would not have been designed. Canalization lines serve this important purpose of isolating the harsh environment from the sensor.

The choice of the size and length of the canalization line is based on the requirements of frequency response of the measurements. Active cooling or heating of the canalization line or introduction of an auxiliary fluid in the canalization line becomes essential when a short length of canalization cannot maintain the sensor within its operating levels. Equally important is the need to actively purge the canalization tube with an inert gas when measurements are done with explosive gas mixtures that could spontaneously burn or detonate when confined in near-stagnant conditions in the canalization tube.

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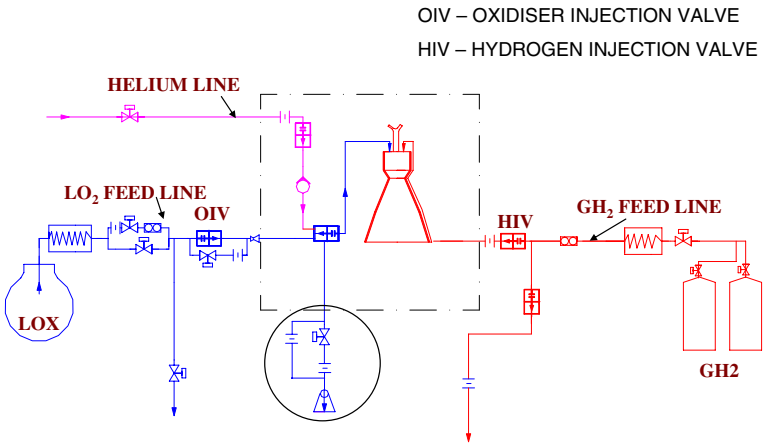

Fig. 1. Details of test set-up.

In certain applications purge gas (an inert gas such as helium/nitrogen) is initially introduced in the oxygen or fuel port to prevent the entry of fuel/oxygen vapors into the supply column and manifold and prevent accidental ignition and explosion. Under these conditions, small quantities of the purge gas enter the canalization line and alter the frequency response characteristics of the canalization.

In experiments involving a rocket thrust chamber using liquid oxygen (LO_2) for oxidizer at a temperature of around 85 K and gaseous hydrogen (GH_2) for fuel at a temperature of 210 K, a canalization line was employed to measure the pressure at which LO_2 is admitted to the combustion chamber. Gaseous helium at room temperature was used as an inert purge gas to flush out the air and prevent the entry and accumulation of GH_2 in the flow passages conveying LO_2. A schematic of the configuration of the GH_2 and LO_2 supply to the chamber and gaseous helium purging is given in Fig. 1. The purge gas enters the LO_2 injection line and the positive pressure prevents the entry of GH_2 into the LO_2 line. The helium purge gas also entered the canalization tube provided for LO_2 injection pressure measurement and ensured protection of the sensor from LO_2 and the cold gaseous oxygen.

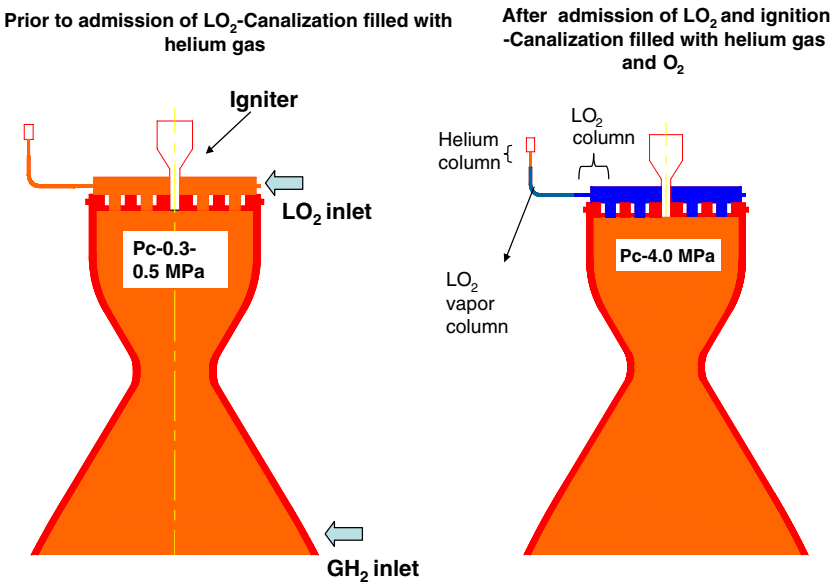

Fig. 2. Schematic of canalization line for LO_2 pressure measurement.