2019-20 NJSGC Fellowship
Poster Presentation

Shock Tunnel Diaphragm Design and Analysis

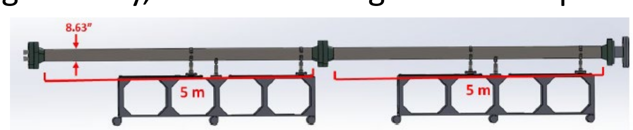
Samantha Schattin
Advisor: Siva Thangam
Department of Mechanical Engineering

Introduction

- The goal is to create a shock tunnel with Mach 6 flow through diaphragm rupture.to analyze flow over various test geometries.
- The tunnel consists of six sections -- the driver, the diaphragm, the driven, the nozzle, test section, and the dump tank.
- The design of a double diaphragm system with an active plunger and a passive blade and its performance analysis is the focus of this work.

Description

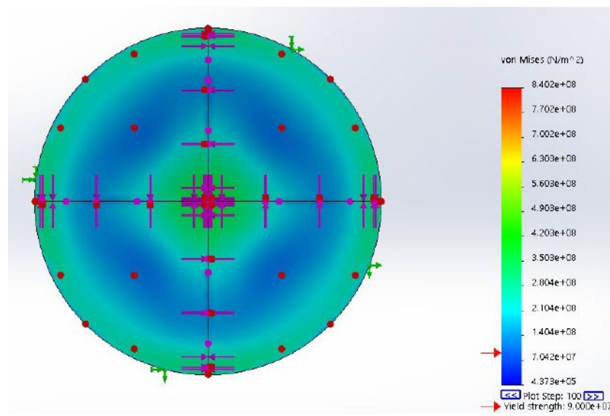
The shock tunnel is constructed with the driver section that can be pressurized to 1000 Psi and raised to a temperature of 600 Kelvin. The shock is initiated by puncturing the first of the two diaphragms with the active plunger to release the high pressure and temperature gas on the second diaphragm, which bulges and is ruptured by the passive blades that are positioned behind the diaphragm. The purpose of the passive blade design was to ensure a “flowering” rupture that generated an effective shock to flow down the driven section and over the test geometry, and exhausting to the dump tank.



The present study analyzed the best possible configuration of the diaphragms to produce an effective burst (or “flowering” rupture). This is critical to the development of a proper shock wave, without which high speed flow analysis over certain geometries is not possible. To determine the best possible diaphragm rupture, experimentation and analysis was completed regarding the design and material used.

Diaphragm Design and Analysis

The shock tunnel is constructed with the driver section that can be pressurized to 1000 Psi and raised to a temperature of 600 Kelvin. The diaphragm design for best possible configuration was realized by a systematic analysis of the stress pattern for various scoring configurations and loading for aluminum, stainless steel and titanium.



Dynamic simulations were performed using SolidWorks to evaluate the deformation or bulge of the second diaphragm and stress distribution at the onset of rupture. It was found that the aluminum diaphragms of 1.5 mm thickness with double cross scoring produced the most effective rupture.

Summary

It was found that both the material selection as well as the scoring technique of the diaphragm, greatly influence the stress field on the diaphragm. This in turn allows for tailoring the areas on diaphragm with stress concentration to facilitate effective rupture.

Acknowledgment

The help from the Stevens Shock Tunnel Team and the Academic Fellowship from NJSGC are gratefully acknowledged.