FLOW MEASUREMENTS IN TRANSONIC FLOWS OF ORGANIC FLUIDS WITH A LUDWIEG TUBE TYPE SETUP

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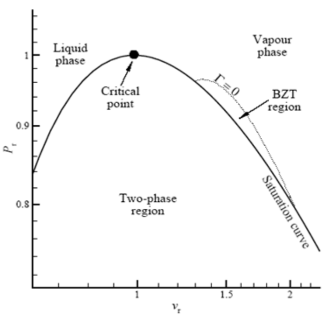
Introduction

Bethe, Zel'dovich, and Thompson were the first scientists to hypothesize the existence of fluids that can exhibit unconventional gasdynamic phenomena. These ensue from the fact that some fluids in single-phase gas regime show a region where the fundamental derivative of the gas dynamics is negative (Γ<0).

Among the BZT fluids there are the siloxanes which are already used as working fluid for the **ORC power plants**.

P-v-thermodynamic plane of an hypothetical BZT fluid



Experimental Setup

Flexible Asymmetric Shock Tube (FAST)

Until now no experimental evidence is available regarding the existence of the unconventional phenomena of the BZT fluids.

Working fluids

At first D_6 ($C_{12}H_{36}O_6Si_6$)has been chosen a as compromise between thermochemical stability and the size of the region with Γ <0

Charge Tube

The charge tube, made by stainless steel (AISI-316), has an inner diameter of 40mm, a thickness of 30mm and a lenght of 9,12m. The maximum fluid pressure and temperature are ~30bar and ~400℃

Fast opening valve

The Fast opening valve, placed into the low-pressure reservoir, has a variable trhoat opening and an opening time of 4ms

Rarefaction Shock wave

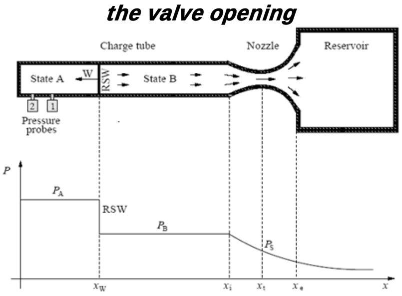
The unconventional phenomenon to investigate is the Rarefaction of the Shock Wave (RSW)

$$V_{RSW} = \Delta L/t$$

ΔL: distance between pressure probes

t: RSW time-of-arrival

Ludwieg Tube and pressure profile after the valve opening



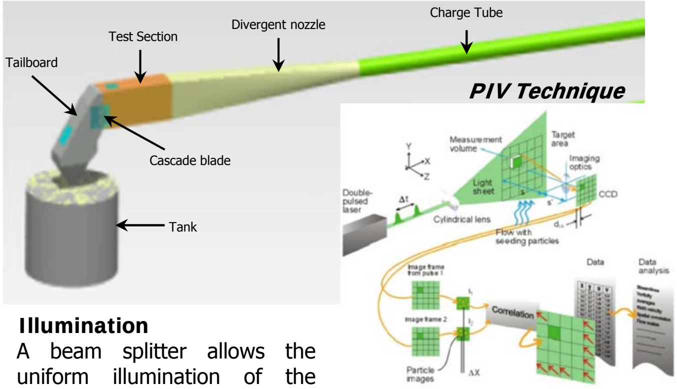
The existence of the RSW will be demonstrated if V_{RSW} is larger than the fluid speed of sound c

Design of a new test rig

A new experimental test rig has been designing to perform visualization and measurements of the transonic flows of organic fluids around blade shapes. The objectives of the project are:

- Validation of the CFD codes for flows of dense organic vapours in conditions typical of ORC turbo-expanders
- Aerodynamic optimization of nozzles

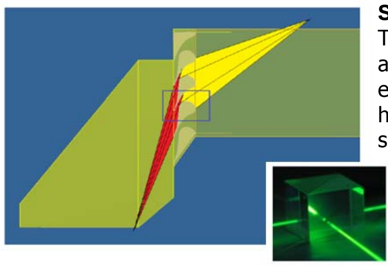
Sketch of the new Shock Tube



PIV Technique

Illumination

A beam splitter allows the uniform illumination of the measurement area



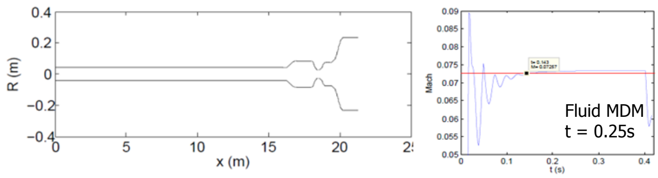
Seeding

Titanium dioxide particles (TiO_2) are suitable for this kind experiments because of their high resistance to thermal shocks and low relaxation time τ

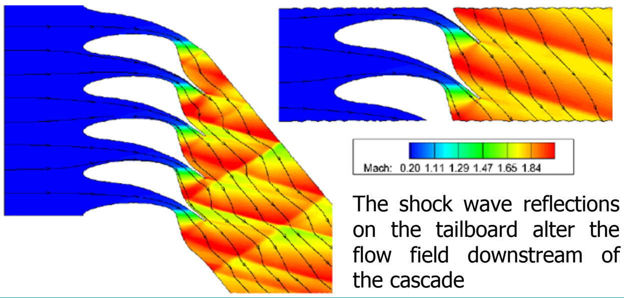
$$\tau = \frac{4\rho_p d_p^2}{3 c_d Re_d \mu_f}$$

Test time estimation

The test time depends on thermodynamic conditions, fluid used, length of the test section and charge tube and clearly area ratio between charge tube and test chamber



Mach number distribution with streamlines superimposed



The shock wave reflections on the tailboard alter the flow field downstream of the cascade

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