IGNITION PROCESS IN SMALL JET ENGINES

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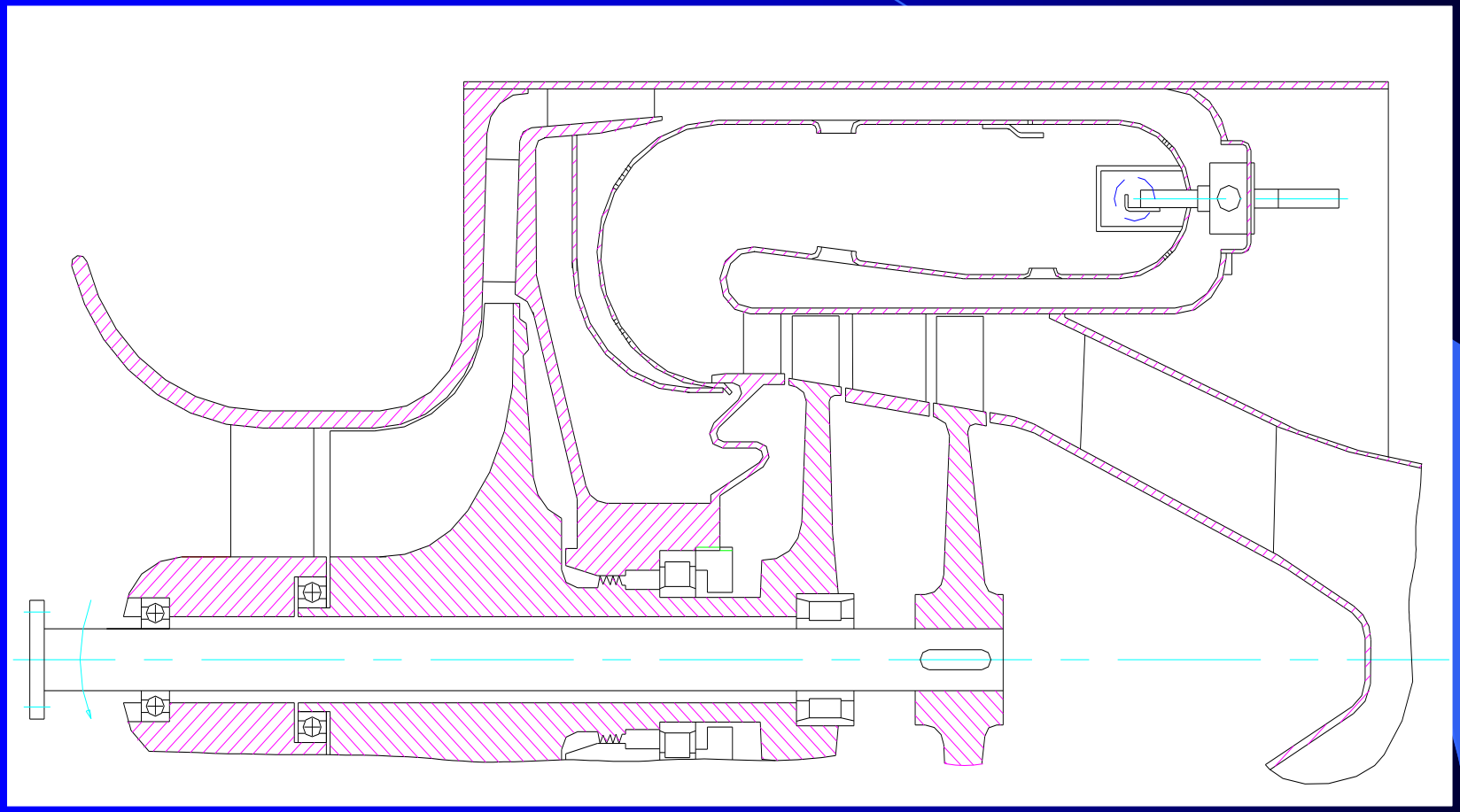
Difficulties in the design of small jet engine injectors:

1.Low fuel flow rate.
2.Low a nozzle pressure drop.
3.Need for simple configurations.

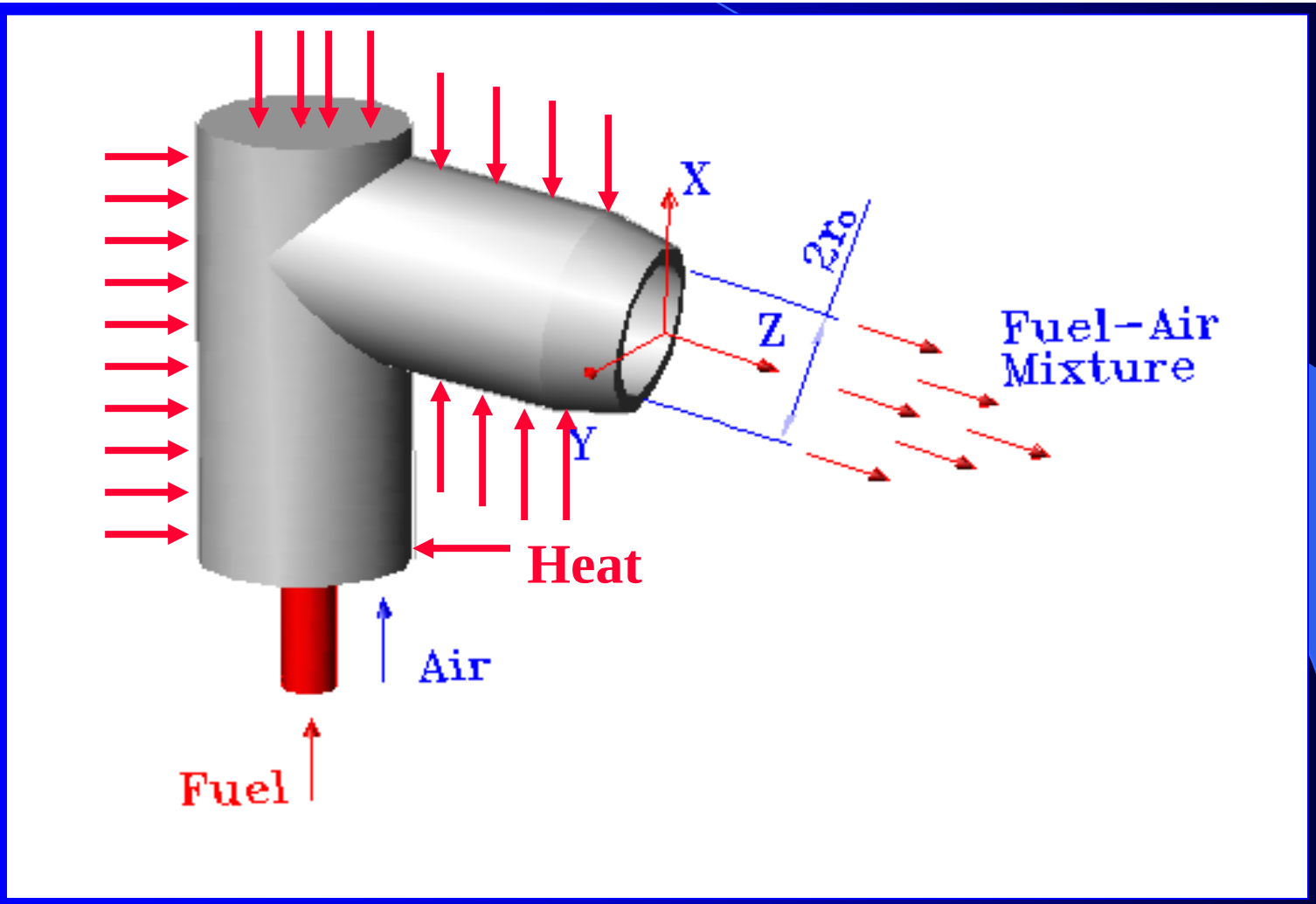
Vaporizer advantages:

Low cost.
Modest fuel-pump pressure requirements.
Low soot formation.

Schematic drawing of a small gas turbine with vaporizer



How does the vaporizer work?



Main drawbacks:

Very poor atomization at start – up (when the vaporizer is cold).

Delicate heat balance

Existing Solutions:

Dual fuel supply systems

Torch igniter

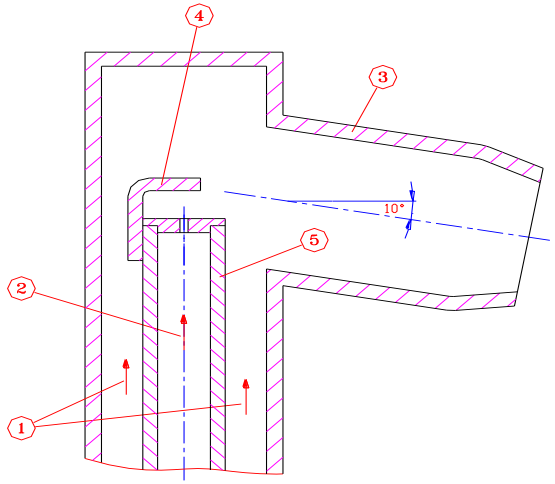
Pyrophoric fuel.

All these solutions complicates the fuel system.

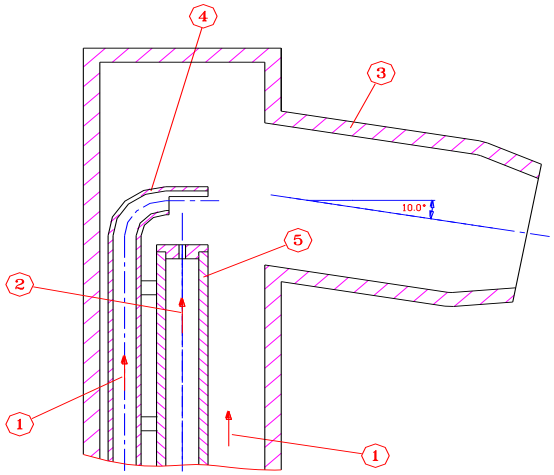
The objective of the present work:

Investigate influence of the aerodynamic and design parameters of combustor (air velocity, air velocity profile at the vaporizer exit, the droplets size and flux distributions, shape of impactor, the igniter location) on the ignition performances and based on these results to minimize needs of ignition supporting systems.

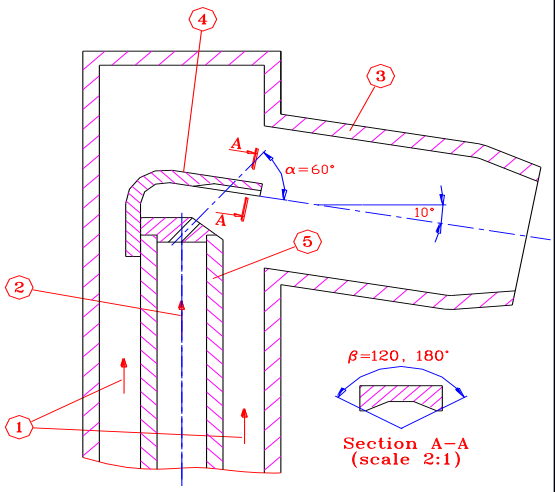
The experimental vaporizer design



Typical Vaporizer

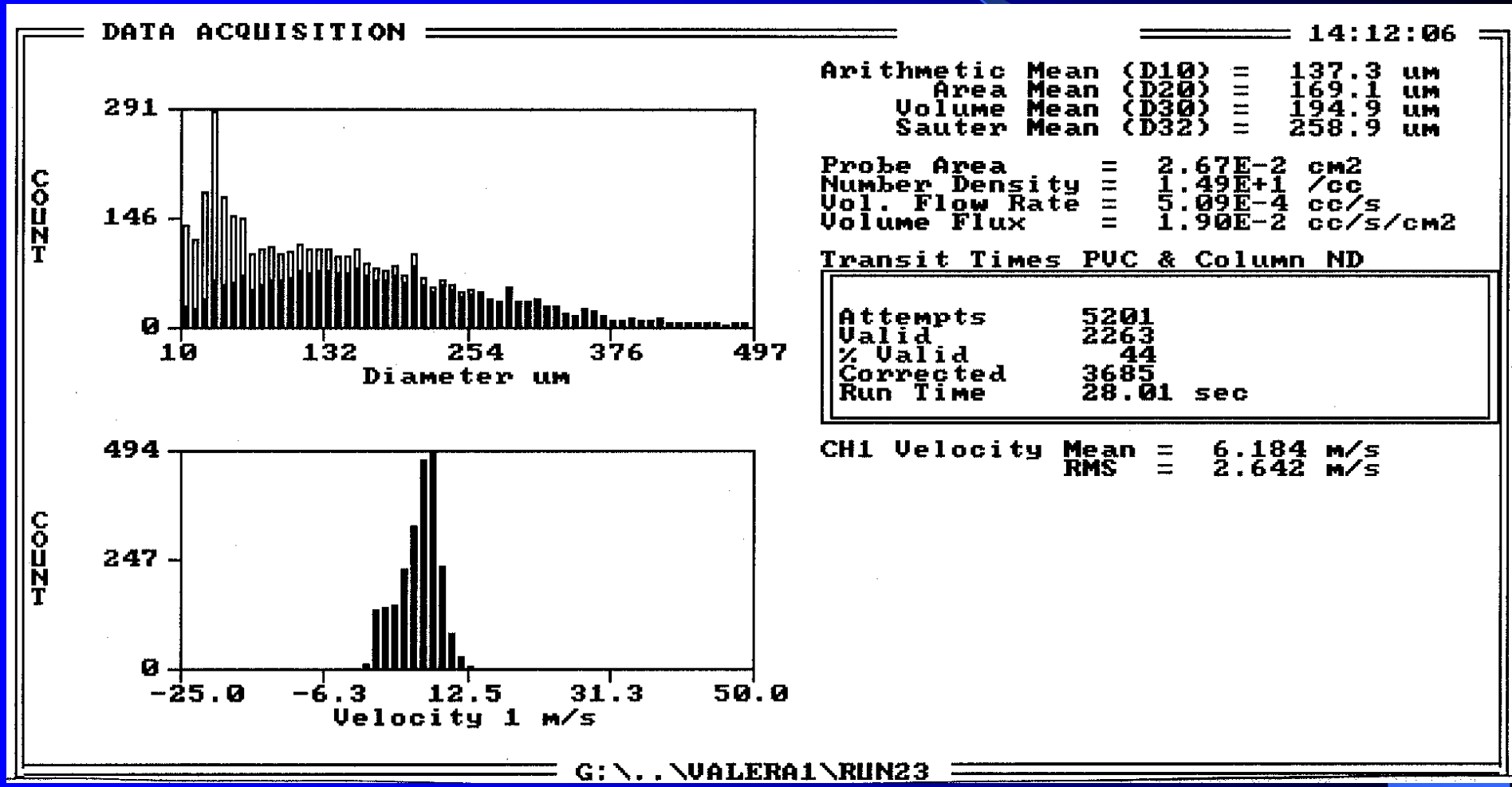


With assisting air



Inclined impactor

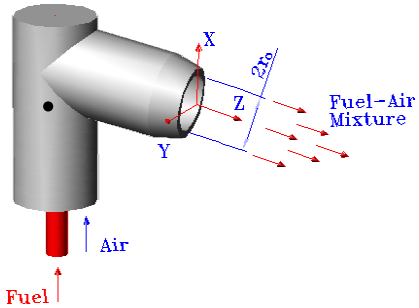
Example of atomization data measurements extracted from PDA system



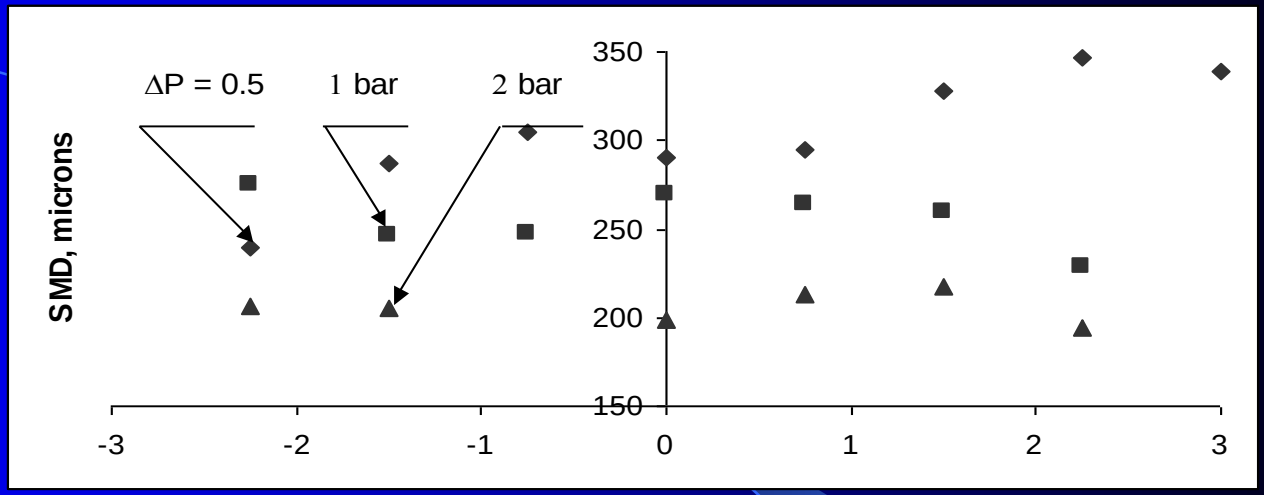
Standard **Modified**

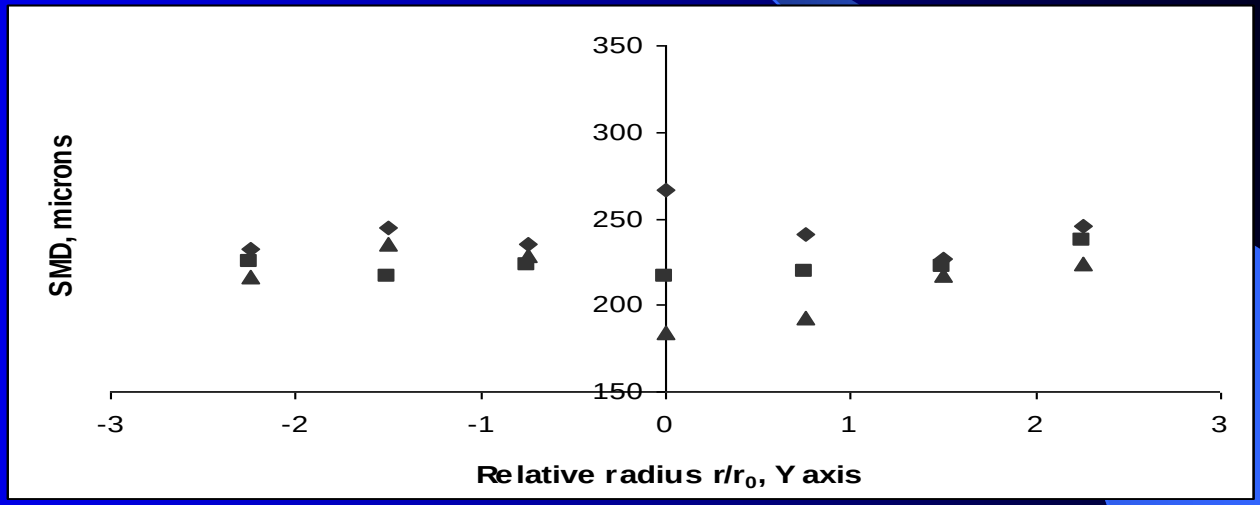
Fuel Pressure = 1.5 bar, Air velocity 20m/s.

Vair=0

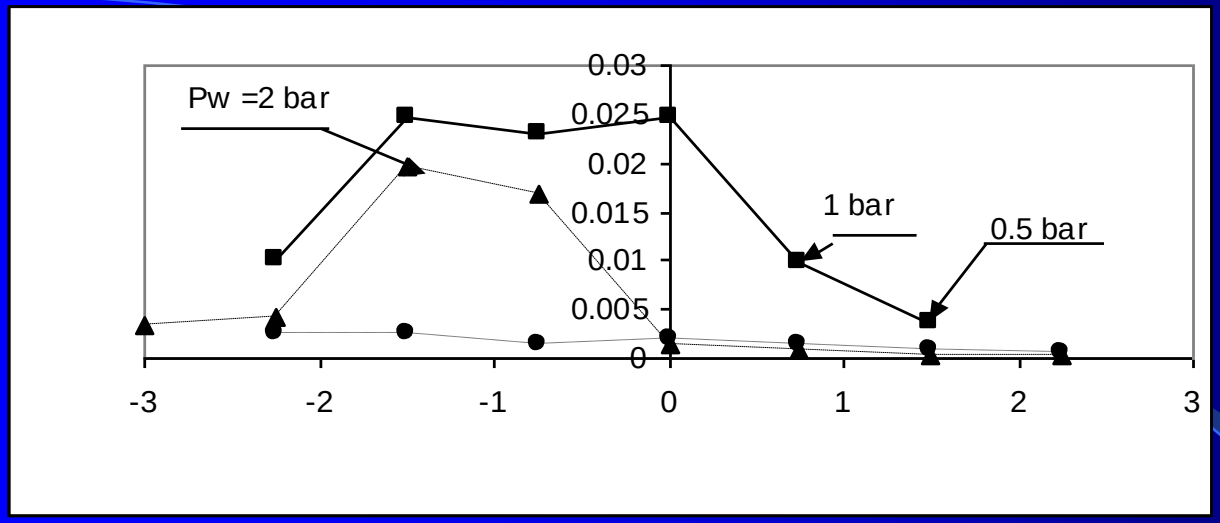


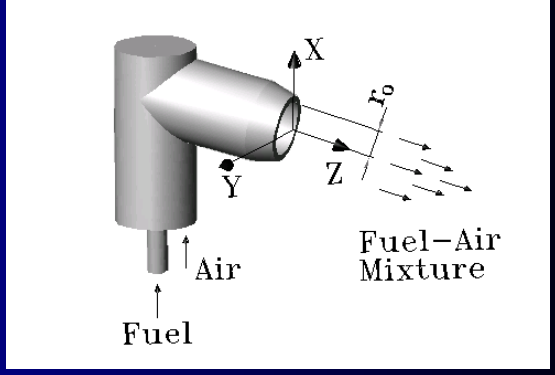
Vair=45 m/s



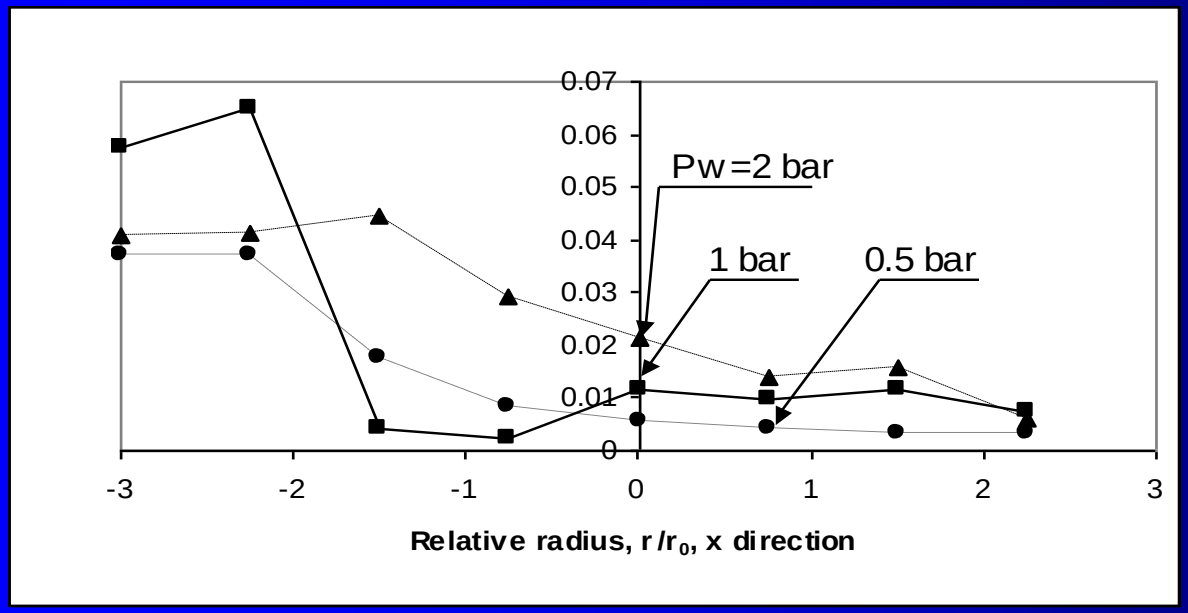


Droplets SMD distribution along the vaporizer radius, (Z = 30 mm, β =120 deg).



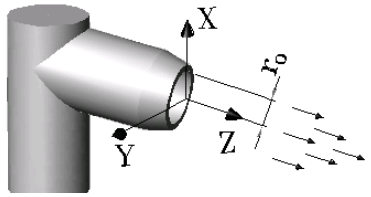


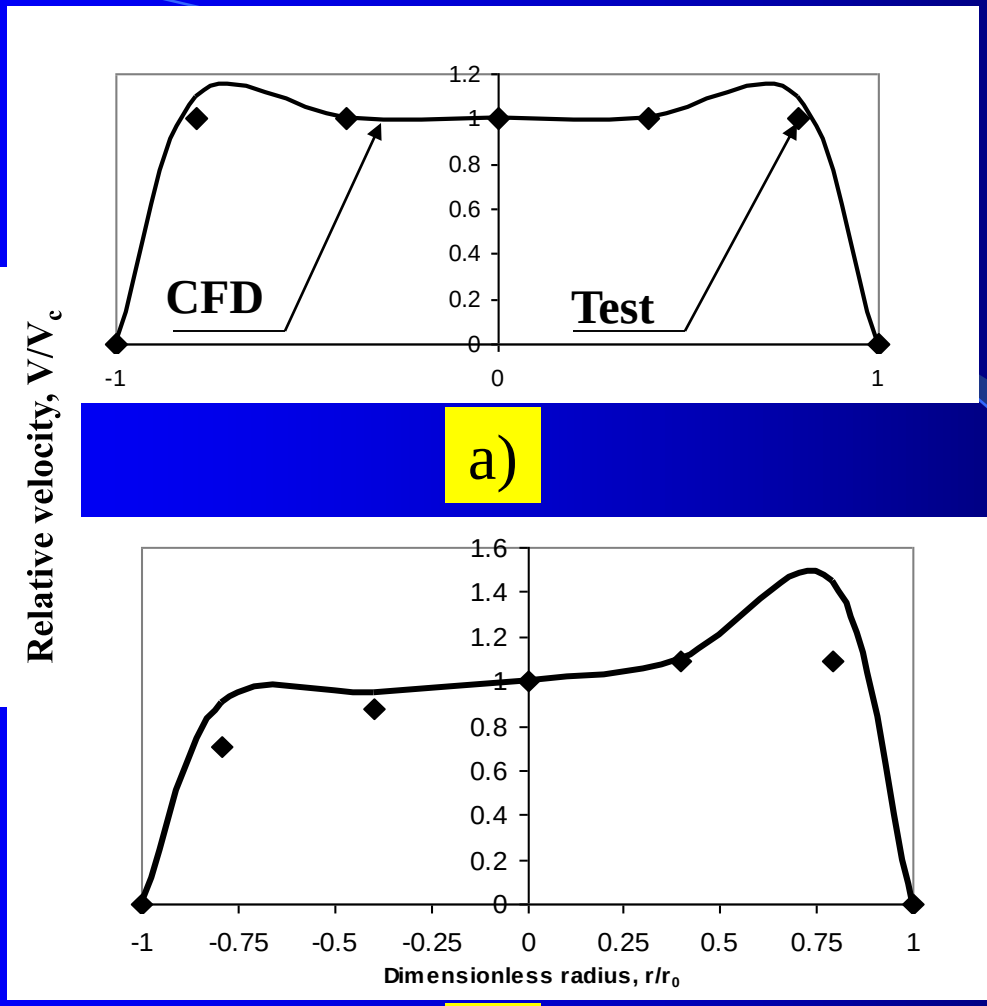
Vair = 0



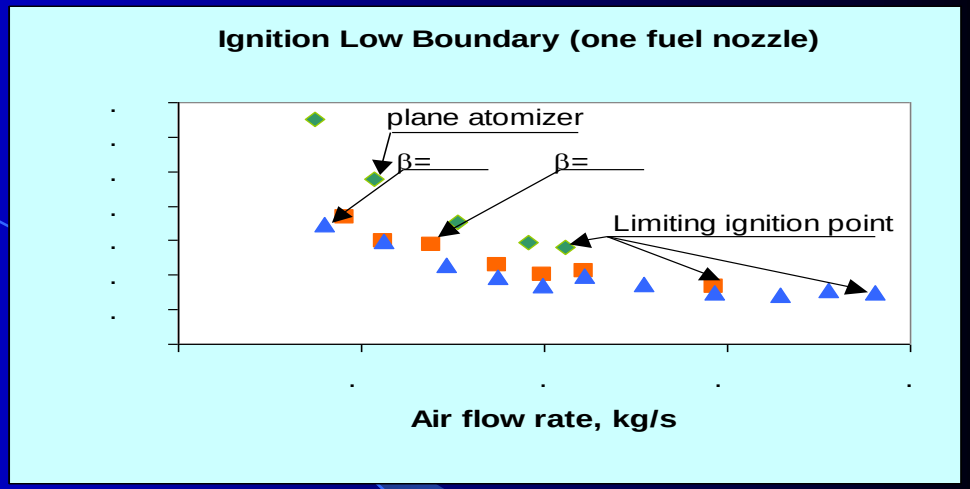
Vair = 45 m/s0

Liquid flux distribution along the vaporizer radius, X direction Z = 30 mm, β = 120 deg.



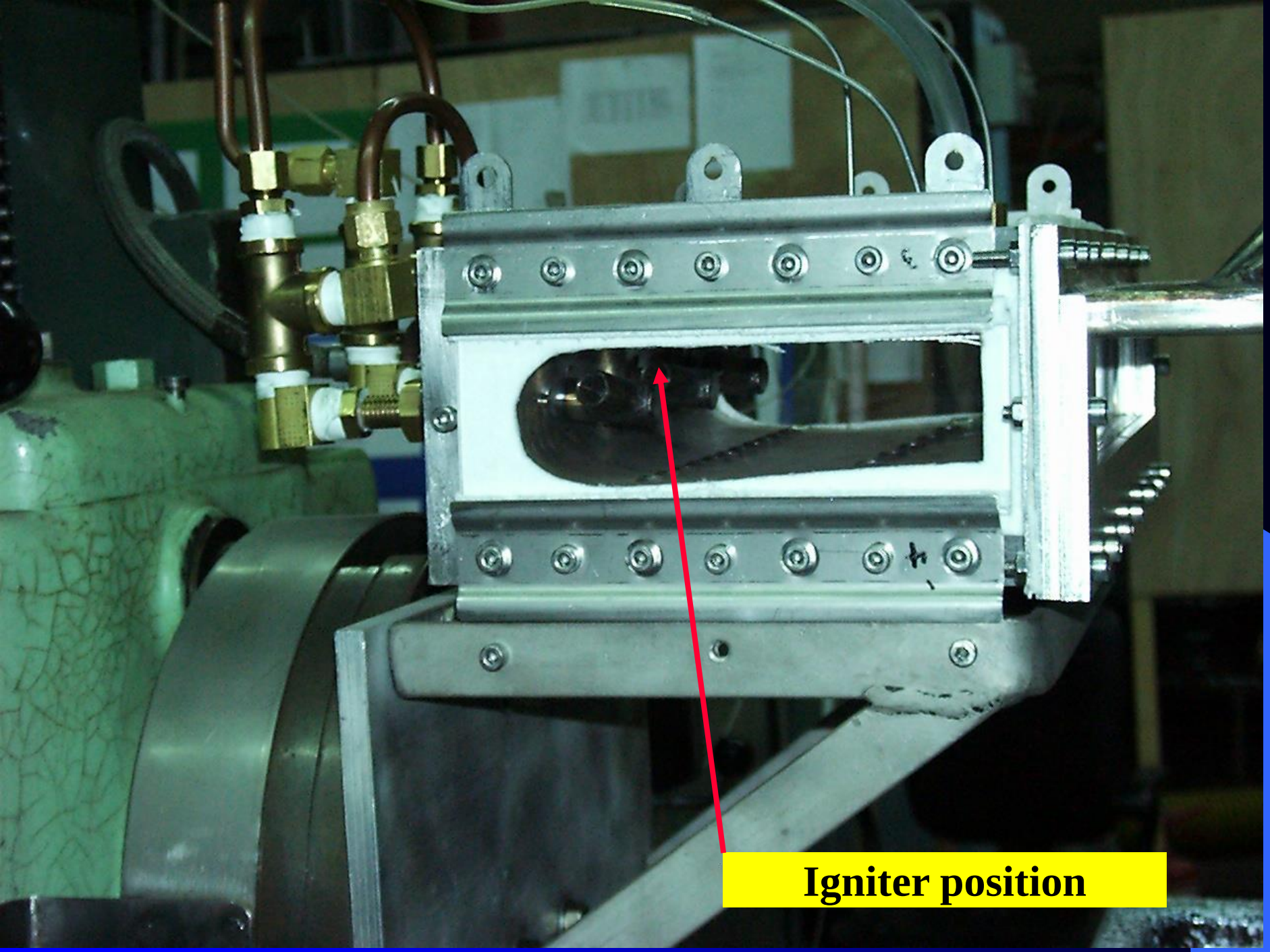


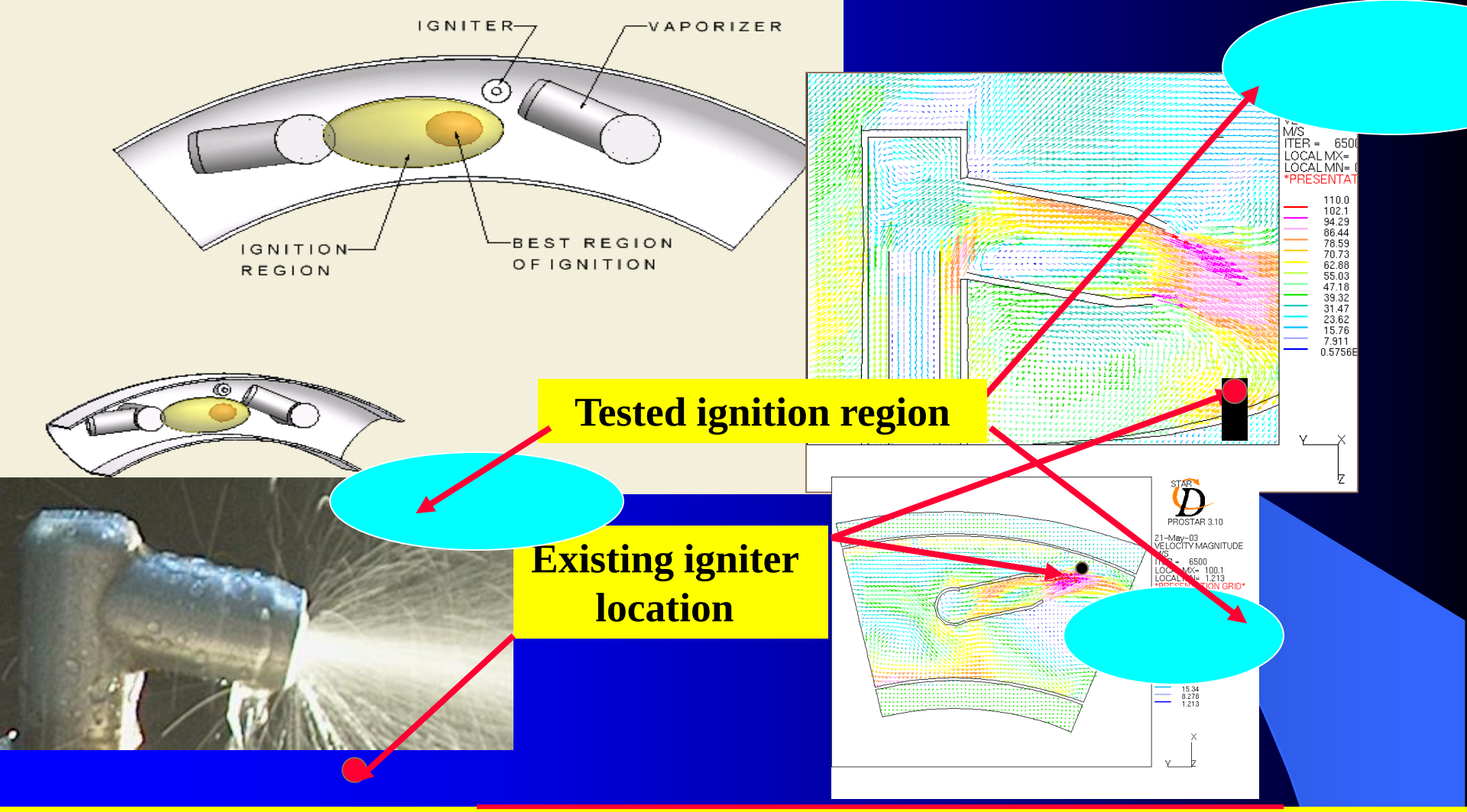
Air velocity distribution at the vaporizer exit (a)-along y-axis, b)-along x-axis).



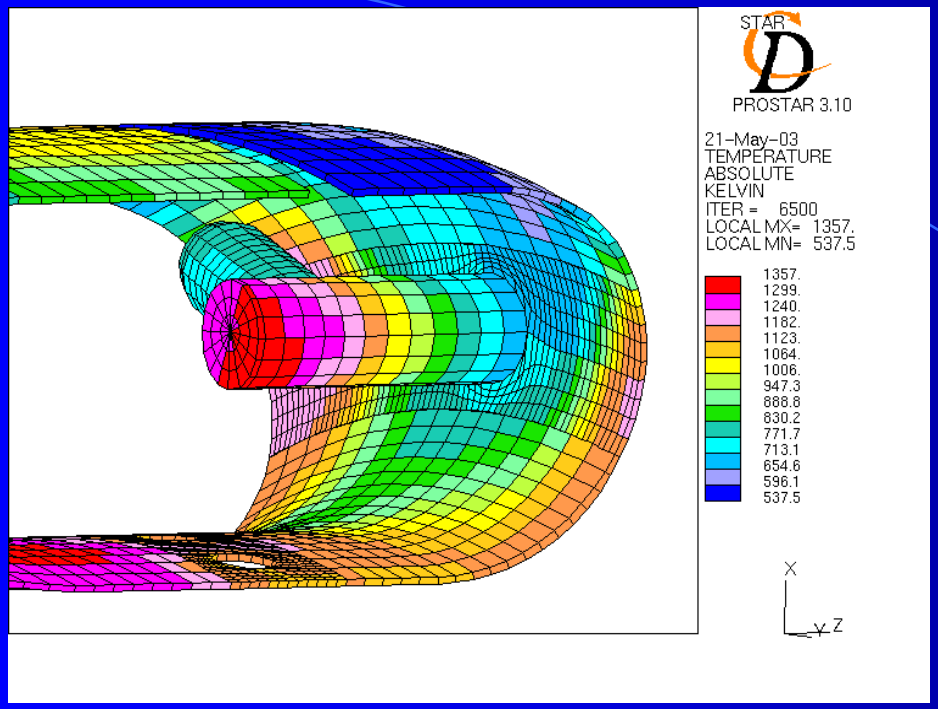
Successful ignition tests were achieved under the following conditions:

- **fuel pressure – 1.5 - 6 bar**
- **fuel/air ratio - 0. 01 – 0.1 (for 3 vaporizers)**
- **averaged air velocity over the liner cross section – 4.5 - 24 m/s**
- **air temperature - 293 K (ambient - 285 K).**
- **fuel temperature - 283 K.**


Igniter position

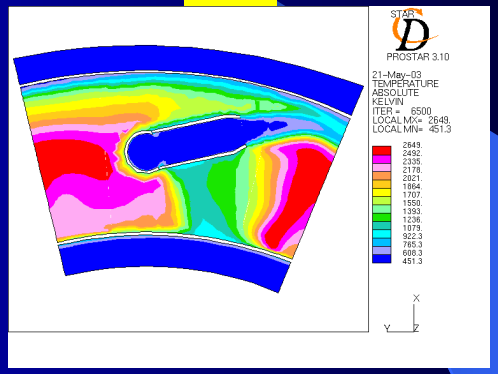


Schematic picture of the igniter location and ignition region (top –front view, bottom - 3-D picture). The existing igniter is located closer to bottom side.



a)

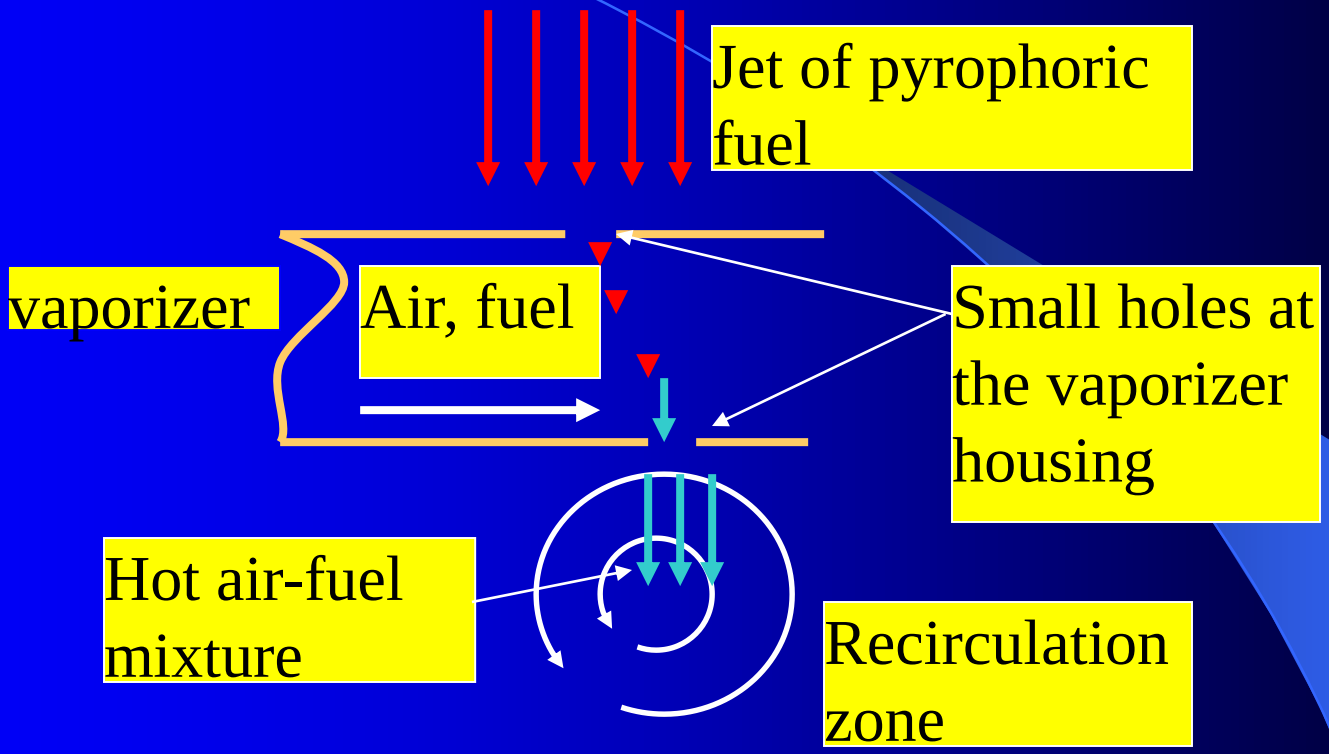
b)



c)

Computer simulation of the temperature distribution at the vaporizer region (a) - at the vaporizer wall, b) – at the section along the combustor, c) – at the cross section of the combustor).

Some remarks about pyrophoric ignition



Schematic drawing of possible vaporizer design for ignition improvement by pyrophoric fuel application.

CONCLUSIONS

Existing vaporizer does not provide spray. Almost all liquid flows through the vaporizer outlet as non-atomized continuous fluid.

Modified impact atomizers demonstrated better atomization quality.

The successful spark ignition over a wide area of the thermodynamic parameters was demonstrated. The igniter location zone and optimal igniter position was found.

It has been found that successful ignition depends strongly on the local droplets diameter and on the air velocity locus at the ignition point and can be achieved even for large average droplets SMD values.