EXEMPLE DE TRAVAUX APPLIQUES A LA CONCEPTION D'UN PETIT MOTEUR DIESEL

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*** INTAKE PORT DESIGN RELATED TO SWIRL AND PERMEABILITY REQUIREMENT**

*** AUTRES TRAVAUX**

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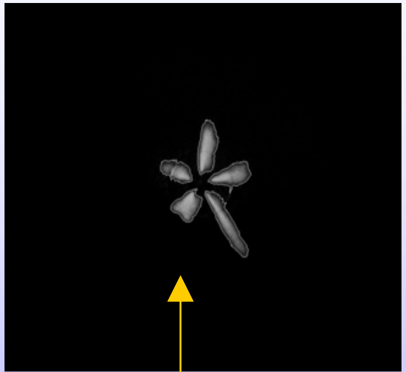
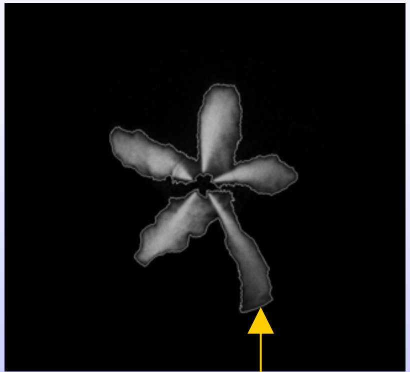
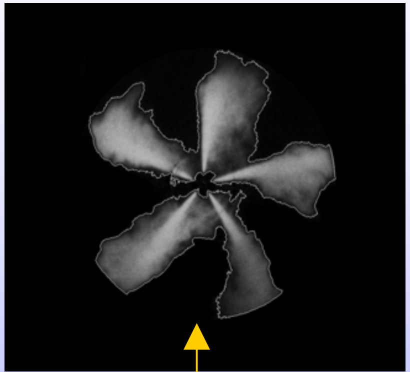
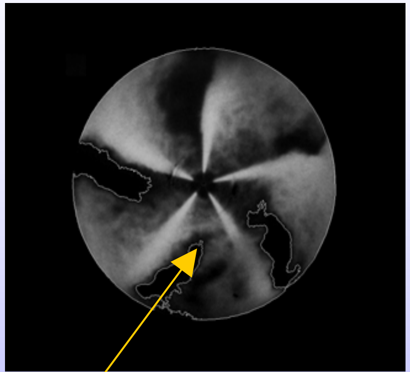
SPRAY INJECTION IN A SWIRLING MOVEMENT
MAIN EVENTS

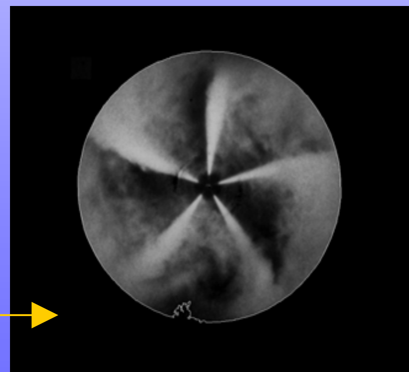
Start of the injection

First spray in contact with the bowl

All sprays in contact with the bowl

Sprays begin to overlap

End of the injection



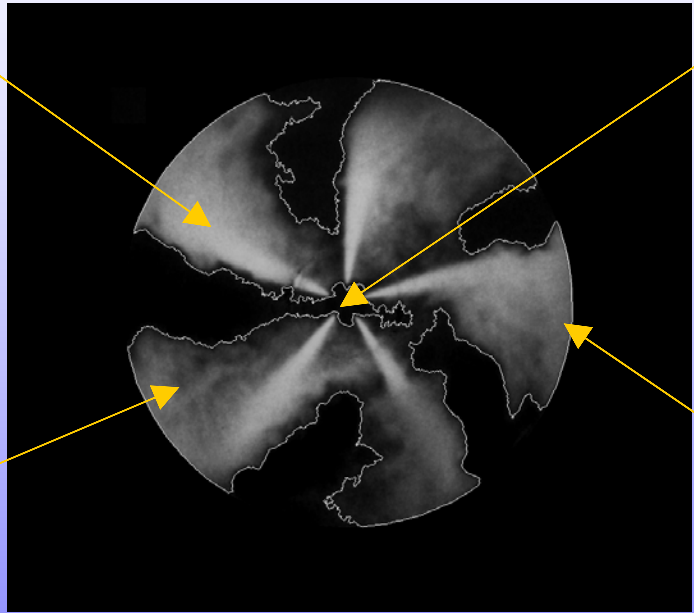
PARAMETERS WHICH REQUIRE TUNING

THE NUMBER OF HOLES

n

THE HOLE DIAMETER

dt



THE SWIRL NUMBER

ω

THE BOWL DIAMETER

Rb

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EVOLUTION OF THE PARAMETERS WHEN REDUCING ENGINE SIZE

THE CRITERIA

The steady flow rate of the injector

The air fuel ratio at impingement

The surface covered by the sprays

THE SOLUTION :

$$R_b, n, d_t \text{ proportional to } L$$

$$\omega \text{ proportional to } 1/L$$

ONE PROBLEM:

Reduction of delay before impingement

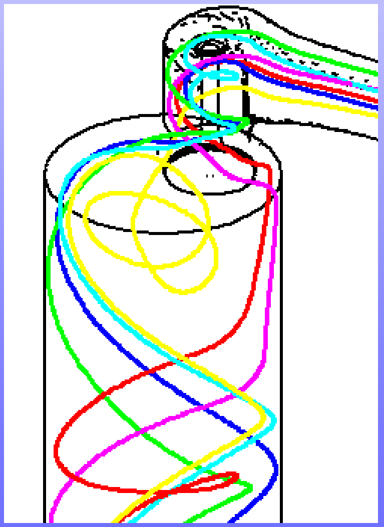
HOW TO CREATE SWIRL

Swirl is created during intake stroke through inlet port(s)

There are two types of inlet ports which create swirl:

- a tangential port : a non-symmetric flow from the valve orifice and the distance between the port and the cylinder axis, create a rotating movement in the cylinder.

- a helical port : a rotating movement is created around the valve stem inside the helical ramp



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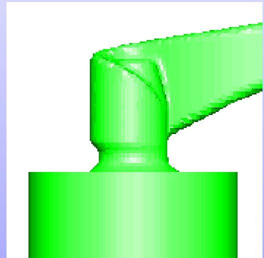
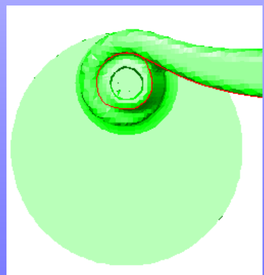
HOW TO CREATE SWIRL

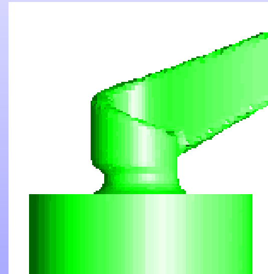
Below are two examples of ports which show the evolution for the same engine, taking into account some technical constraints (valve stem guide) and improvement of discharge coefficient and swirl.

Port 1





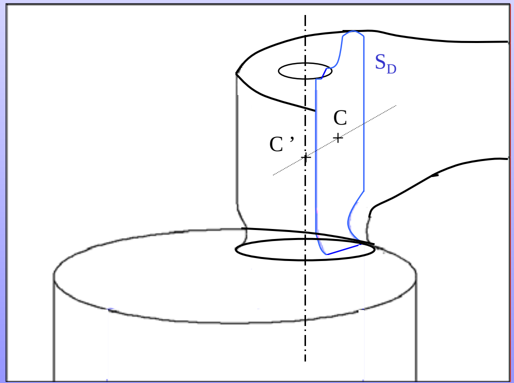
Port 2

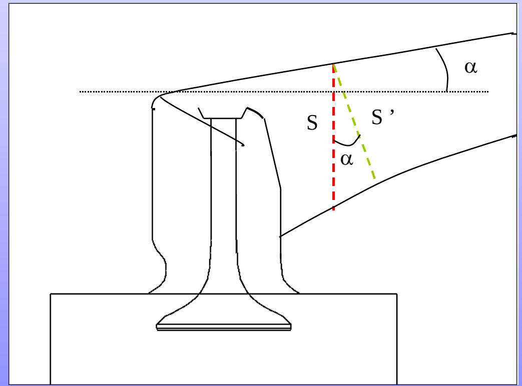


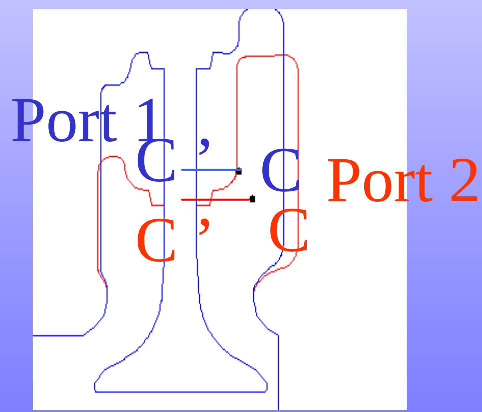
GENERATION OF SWIRL:

Angular momentum flux at helical ramp inlet:

$$\iint_{S_D} u_t \cdot r \cdot (\vec{u} \cdot \vec{n}) \cdot ds \approx \frac{q^2 \cdot CC' \cdot \cos(\alpha)}{\rho \cdot S_D^{'}}$$

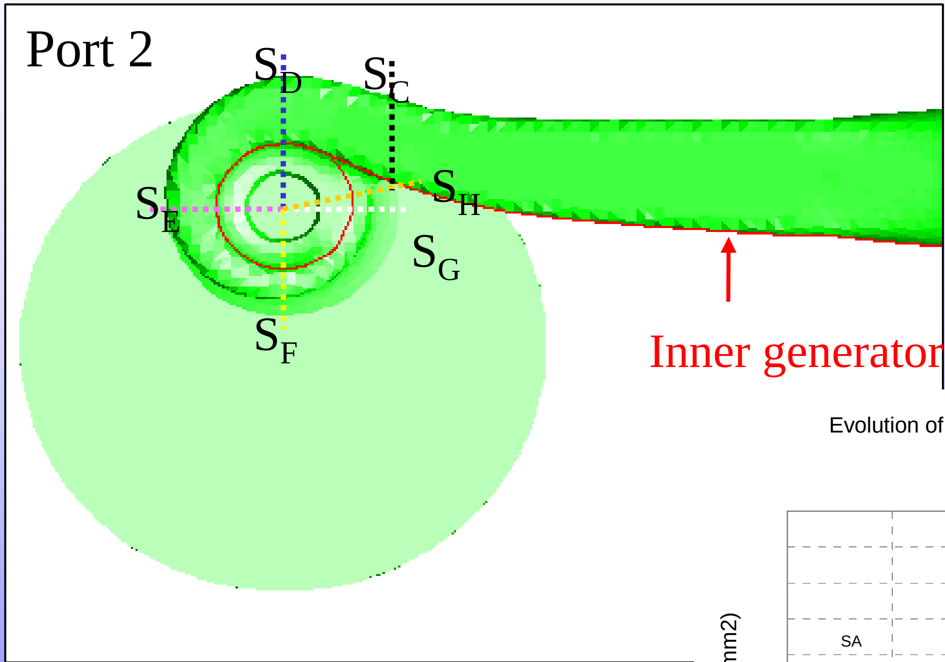


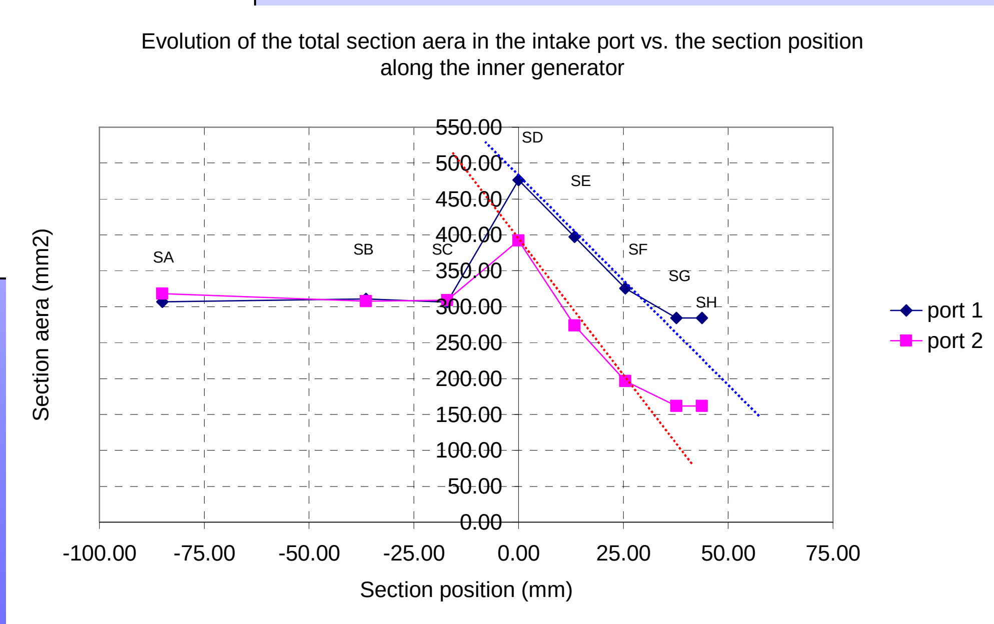




PARAMETERS WHICH MODIFY SWIRL:

EVOLUTION OF SECTION AREA ALONG HELICAL RAMP





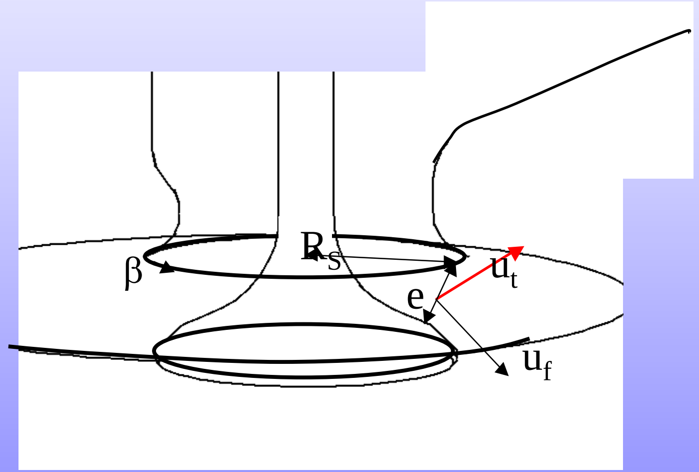
Slope ratio of port 1 related to port 2: 80%

PARAMETERS WHICH MODIFY SWIRL:

EVOLUTION OF SECTION AREA ALONG HELICAL RAMP

Momentum flow at helical ramp inlet is converted into swirl.
A good hypothesis for reducing pressure loss is that tangential (u_t) and flow velocity (u_f) are constant around valve seat.
In this case:

$$-\frac{dS}{d\beta} = R_S \cdot e \cdot \frac{u_f}{u_t}$$



For identical valve seat:

$$\frac{C_u}{C_a} = K \cdot \left(-\frac{dS}{d\beta} \right)^{-1}$$

A ramp with weak slope increases swirl.

The rate of variation dS/dβ is nearly proportional to tan(α).

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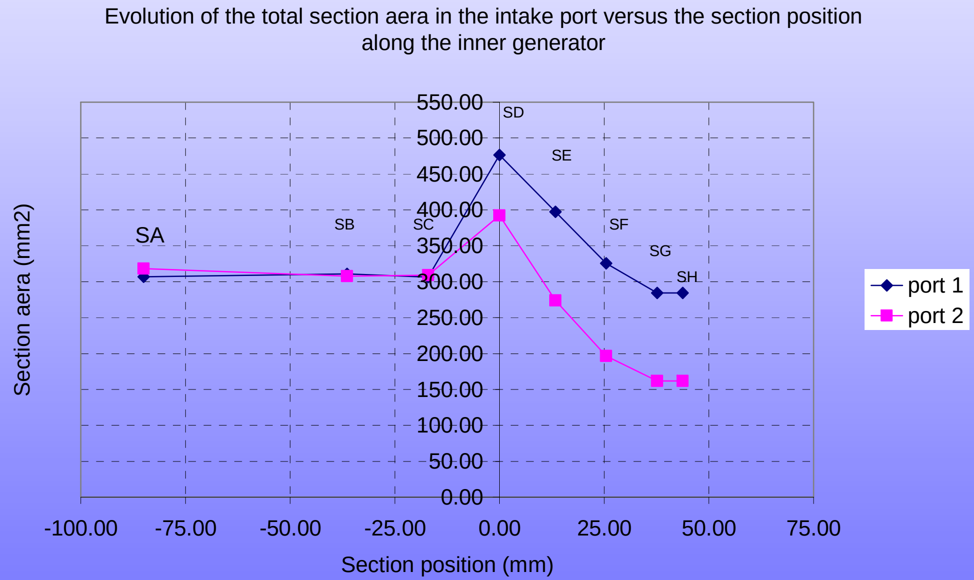
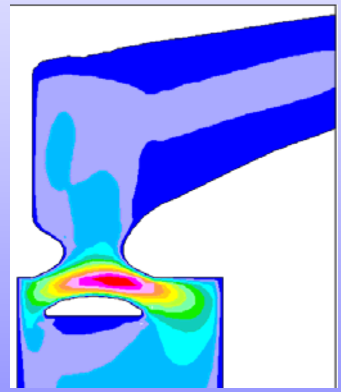
PARAMETERS WHICH MODIFY SWIRL:

SUDDEN SECTION VARIATION

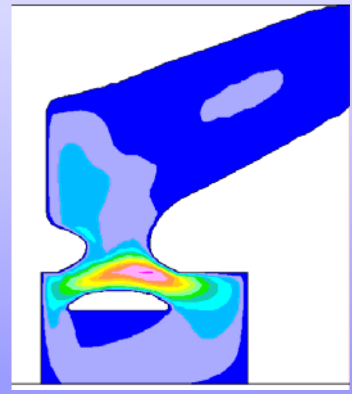
-generates recirculation flow and pressure loss,
-can make more uniform velocity at valve seat, but with increase of pressure loss due to friction.



Port 1



Port 2



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PARAMETERS WHICH MODIFY SWIRL:

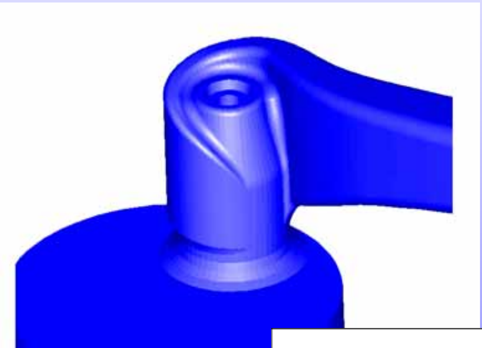
FLOW GUIDANCE AT THE RAMP PERIPHERY.

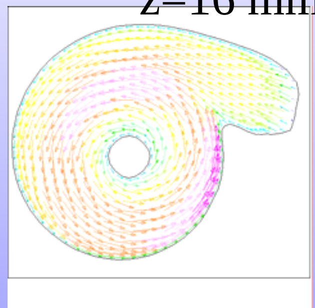
This guidance is more important and longer for the port 2: the angular momentum flux is more forced, and thus swirl is higher. But the velocity field in the valve seat is less uniform. Port 2 acts partially as a tangential port.

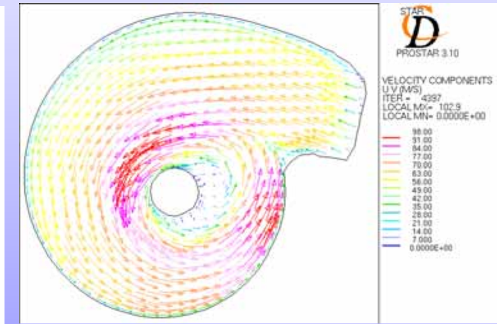
Port 1

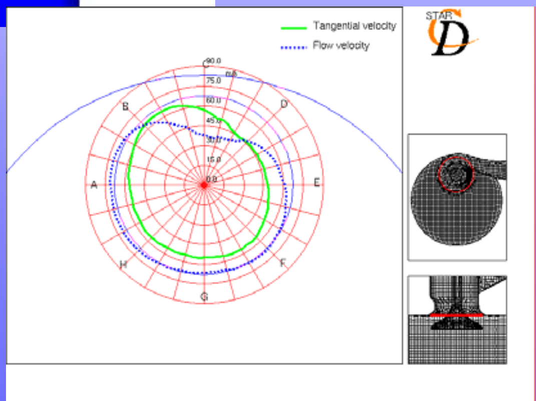
z=16 mm

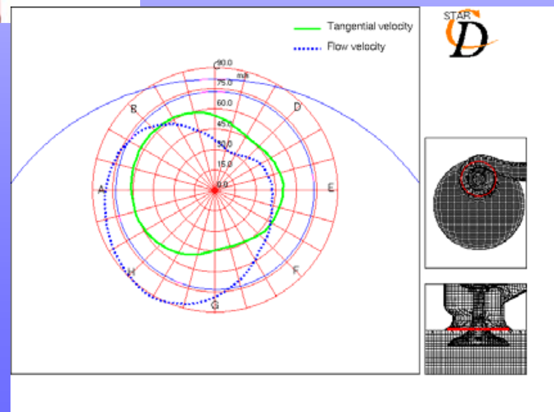
Port 2









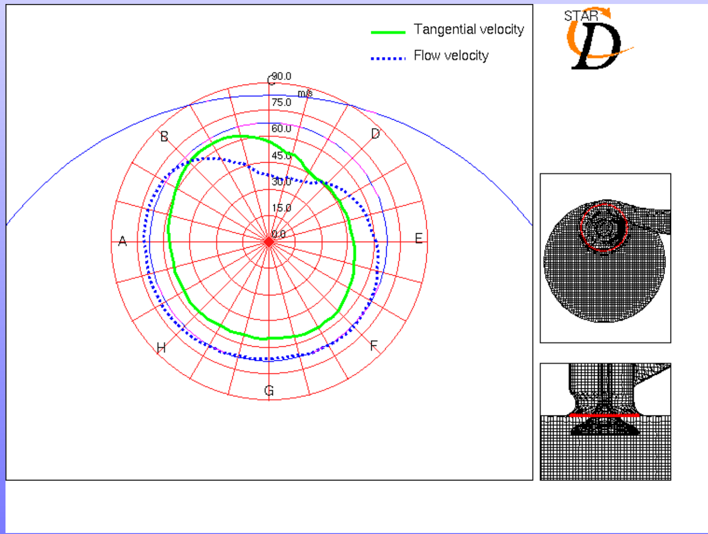


PARAMETERS WHICH MODIFY SWIRL:

PORT POSITION IN RELATION TO CYLINDER WALL.

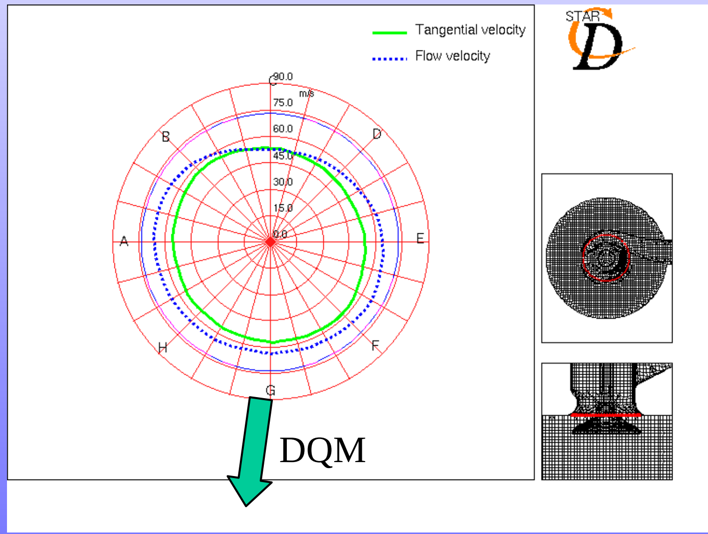
For a helical port, proximity of wall can disturb velocity uniformity at the valve seat, and thus decrease swirl and discharge coefficient.

Port 1



$Cu/Ca=3.95; C_D=0.476$

Port 1 centred



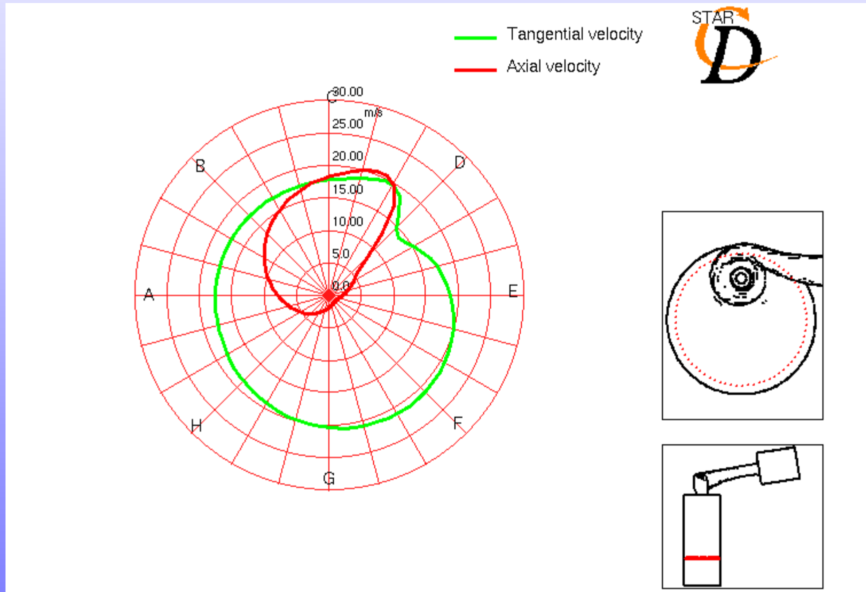
$Cu/Ca=4.52; C_D=0.490$

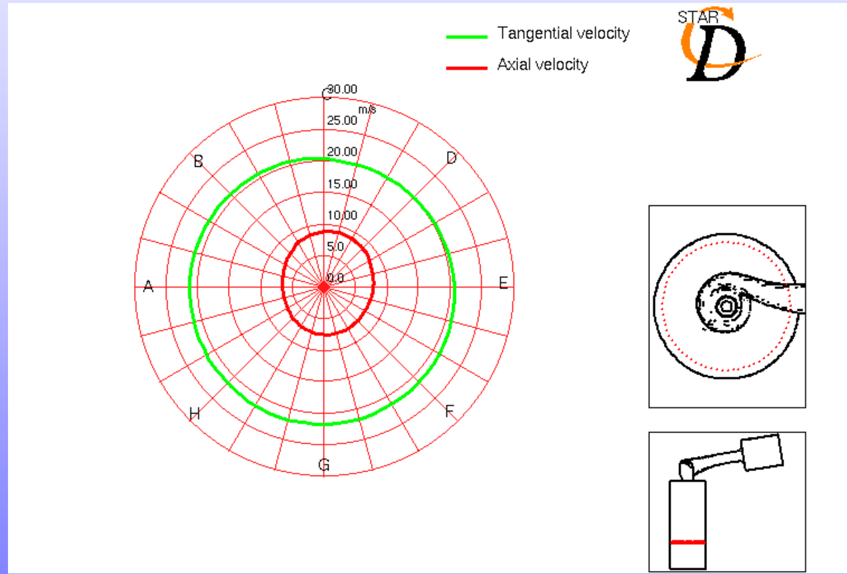
PARAMETERS WHICH MODIFY SWIRL:

PORT POSITION IN RELATION TO CYLINDER WALL.

Port 1

Port 1 centred





Cu/Ca=3.95; C_D=0.476

Cu/Ca=4.52; C_D=0.490

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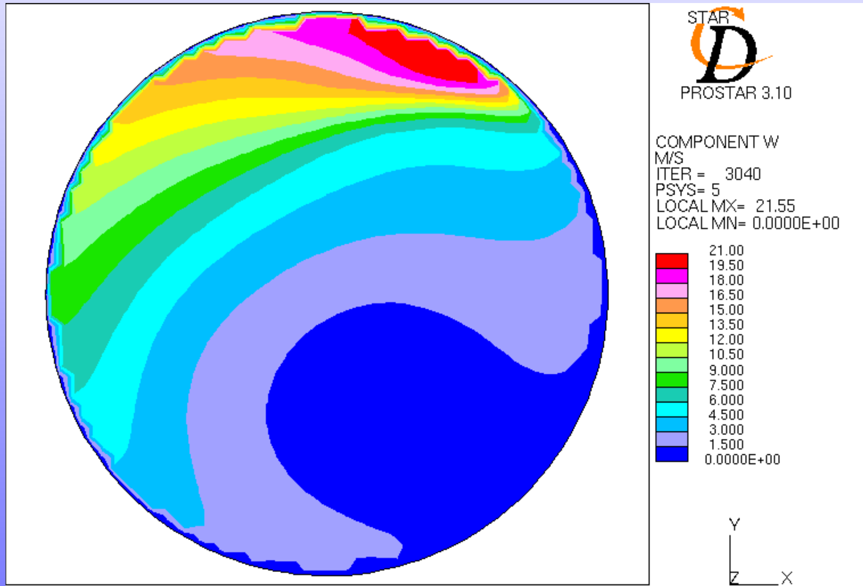
PARAMETERS WHICH MODIFY SWIRL:

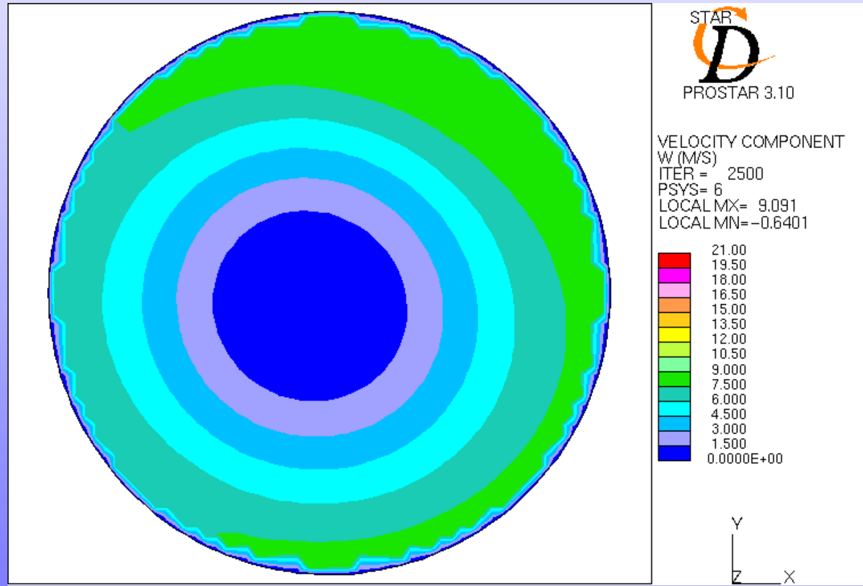
PORT POSITION IN RELATION TO CYLINDER WALL.

Axial velocity

Port 1

Port 1 centred





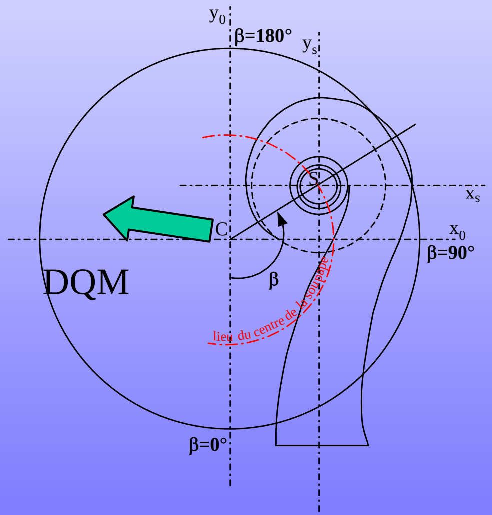
$Cu/Ca=3.95; C_D=0.476$

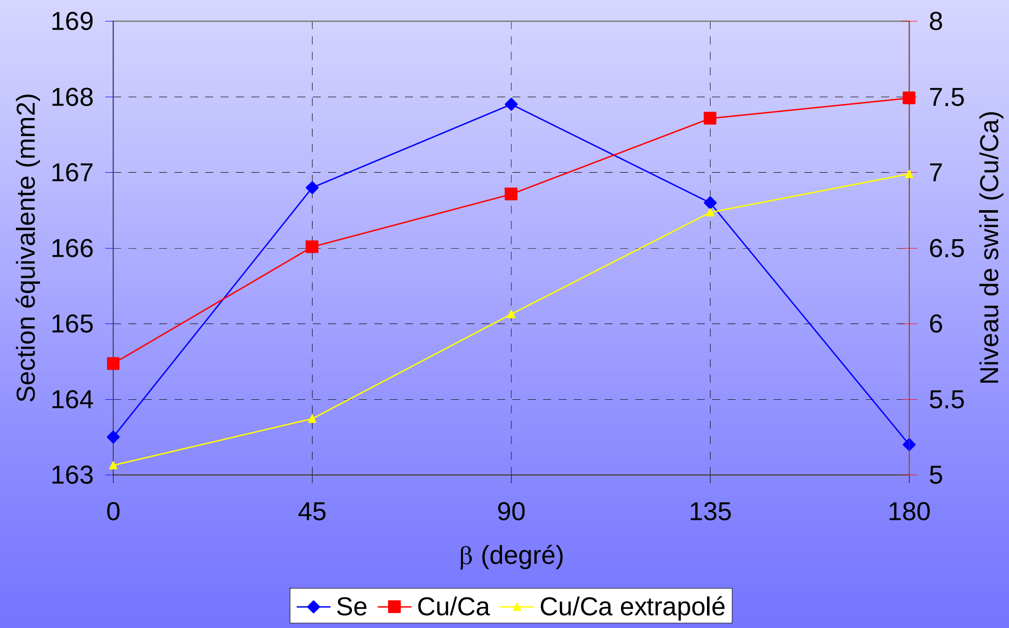
$Cu/Ca=4.52; C_D=0.490$

PARAMETERS WHICH MODIFY SWIRL:

LOCATION OF PORT RELATIVELY TO CYLINDER WALL.

The effect of wall proximity depends on orientation of the port relatively to the radius .





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COMPARISON OF PORT 1 AND PORT 2:

Port 1: Cu/Ca=3.95 ; C_D=0.476
Port 2: Cu/Ca=5.34 ; C_D=0.466
<u>Main causes:</u>

- slope of helical ramp : $(-dS/d\beta)_2 / (-dS/d\beta)_1$ =1.2
- distance CC' : $(CC')_{2/}(CC')_1$ =1.2
- flow guidance at the entry of the port 2 helical ramp

Due to Cu/Ca increase, port 2 discharge coefficient should theoretically decrease by the ratio:

$$\left(\sqrt{1-\left(C_D\cdot\left(\frac{C_u}{C_a}\right)\cdot\frac{\Phi_s}{B}\right)^2}\right)_{port2}\Bigg/\left(\sqrt{1-\left(C_D\cdot\left(\frac{C_u}{C_a}\right)\cdot\frac{\Phi_s}{B}\right)^2}\right)_{port1}=0.973$$

(ϕ_s : Valve seat diameter)

In fact, discharge coefficient decrease is only 2% .
Pressure loss is due to other factor than swirl.
In particular, sudden area variation at helical ramp of port 1 affects pressure loss.

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CONCLUSIONS:

When reducing engine size, we have to decrease hole diameter, number of holes, bowl diameter and increase swirl level.

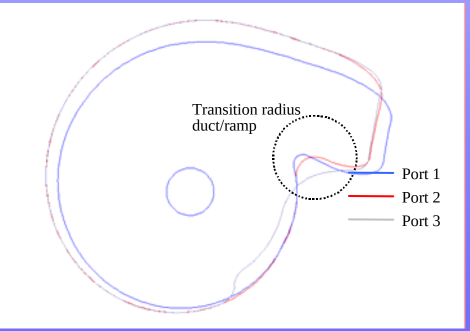
Main helical port parameters which control swirl level are:

- section area evolution in helical ramp,
- lever arm at helical ramp inlet,
- flow guidance in helical ramp,
- port orientation related to cylinder wall,

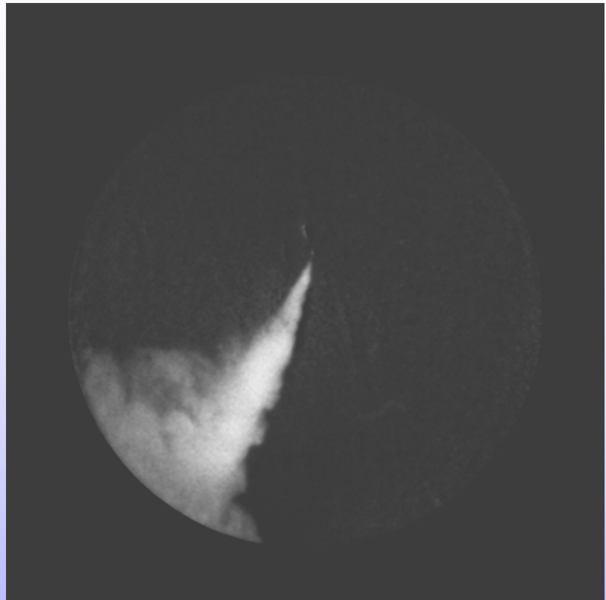
And other geometrical details as:

- transition radius between the upstream pipe and the helical ramp end,

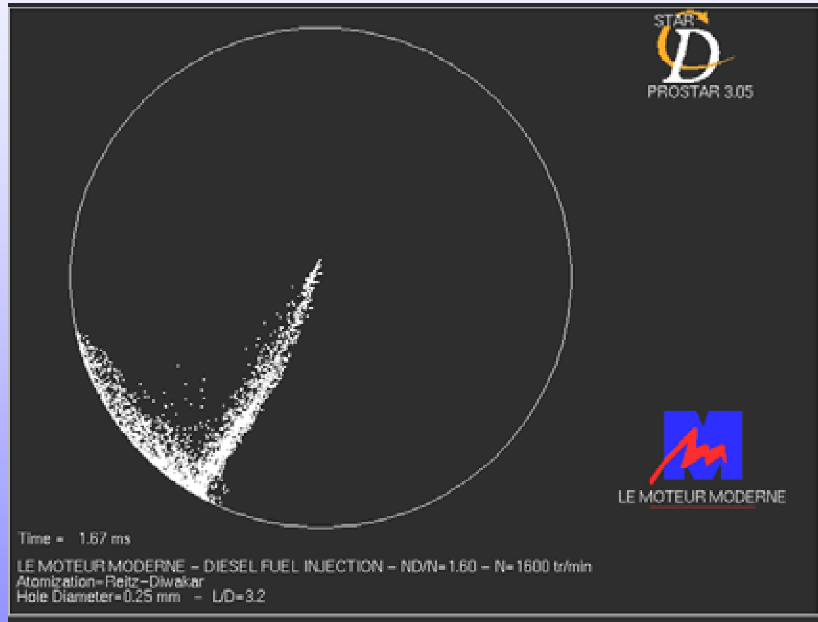
  Ex: Port 3, similar to port 2 but with a different radius: Cu/Ca=4.42 , C_D=0.55
- ...



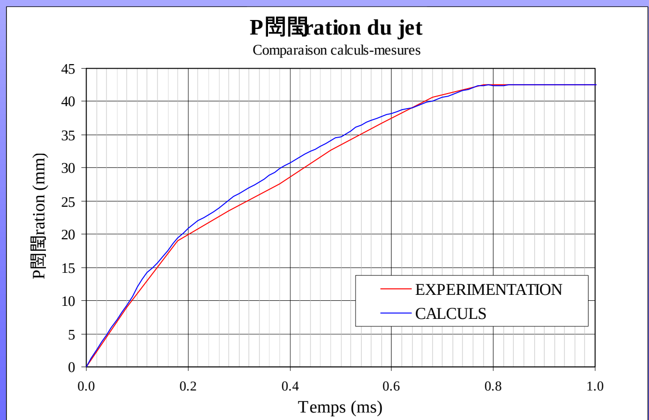
Autres travaux: INJECTION DE CARBURANT



Images obtenues par cinématographie rapide
puis traitement et analyse des images
avec un injecteur mono-trou dans une chambre avec swirl



Injection de carburant obtenue par calculs STARCD avec le même injecteur



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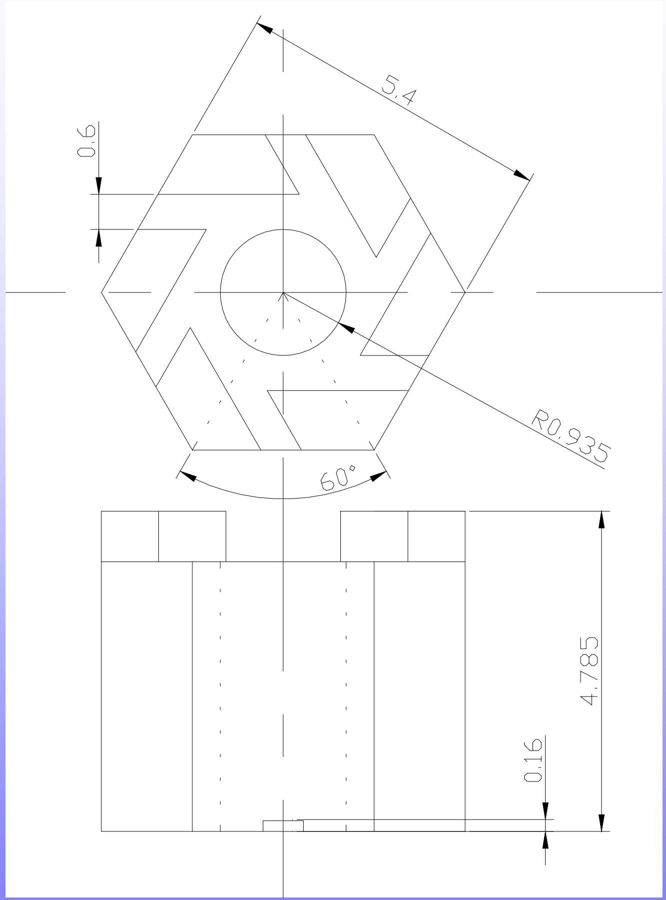
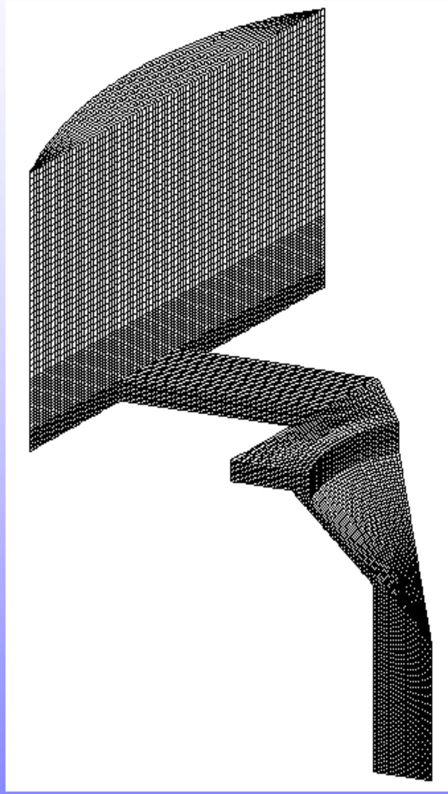
Autres travaux: **INJECTION D ' ESSENCE**





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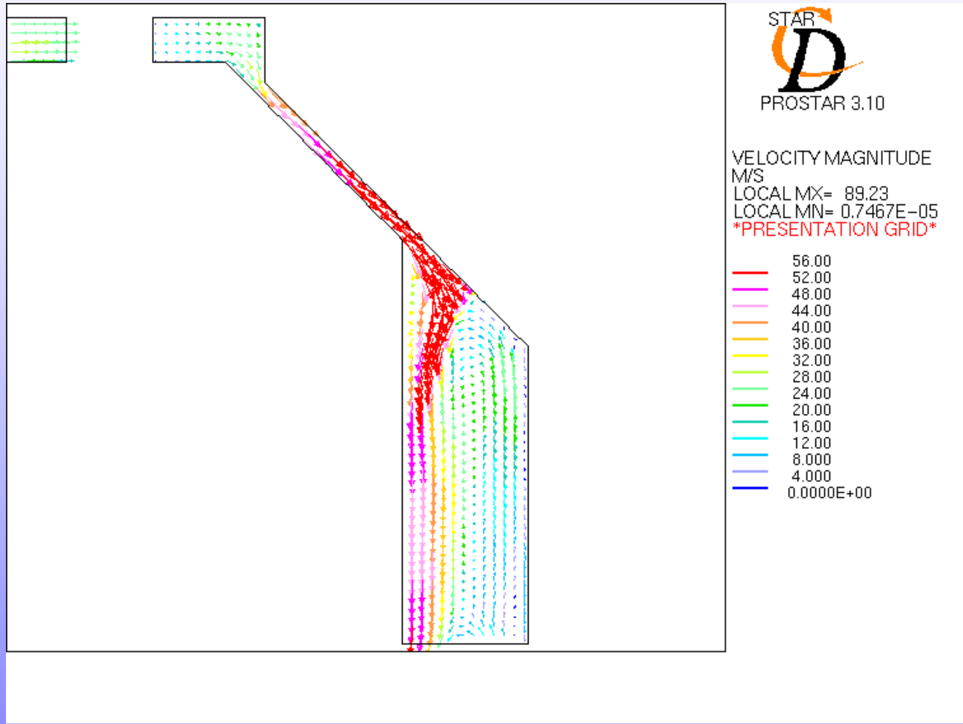
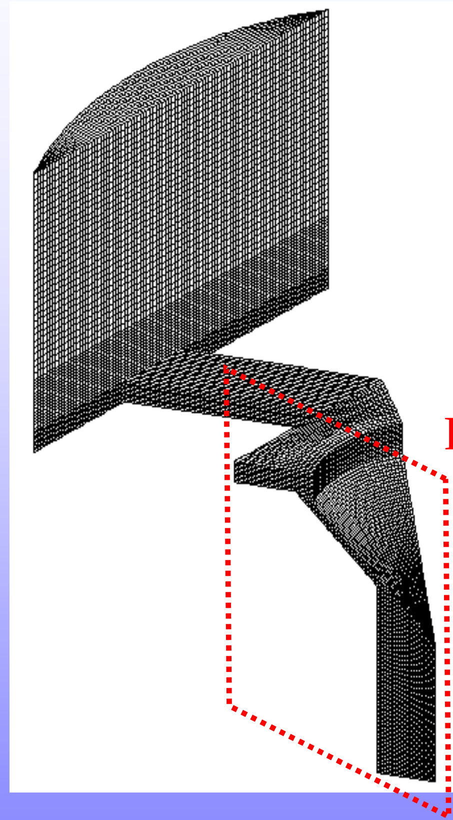
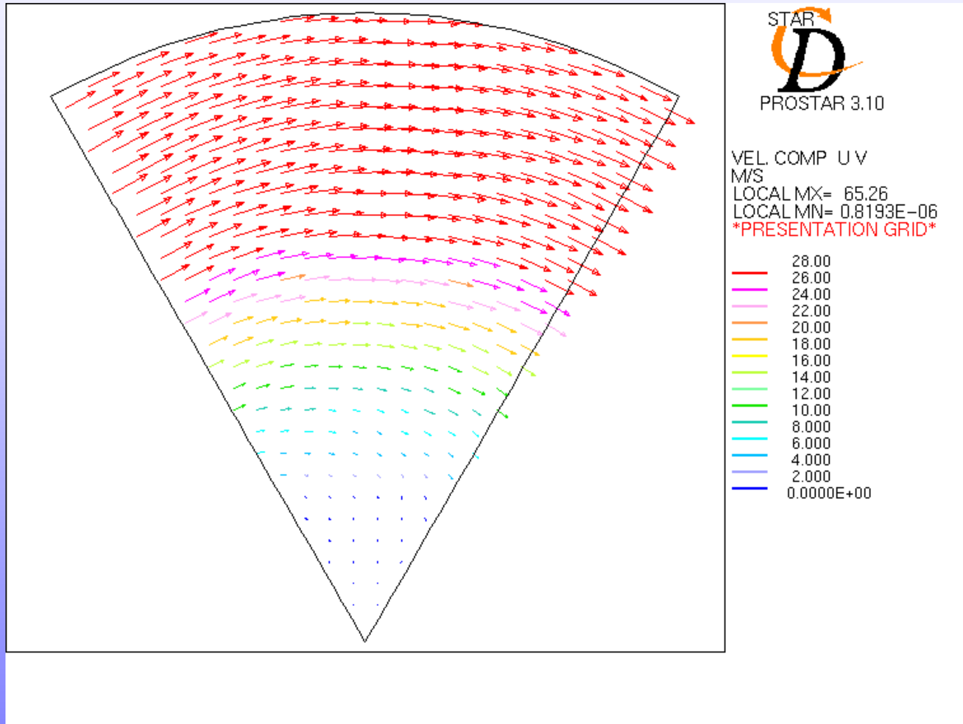
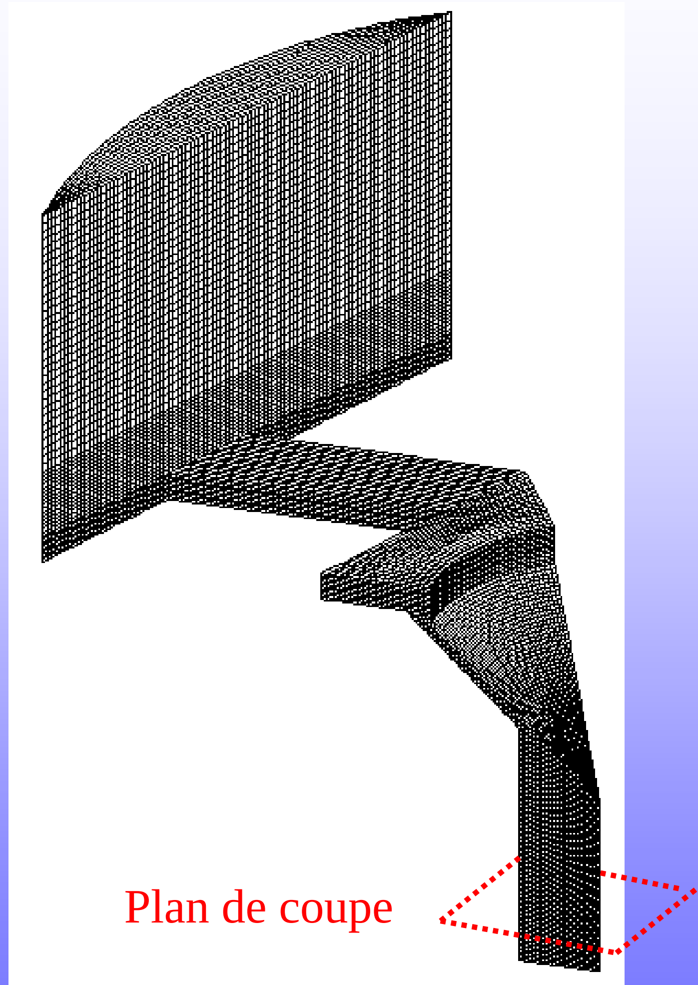
Autres travaux: INJECTION D ' ESSENCE





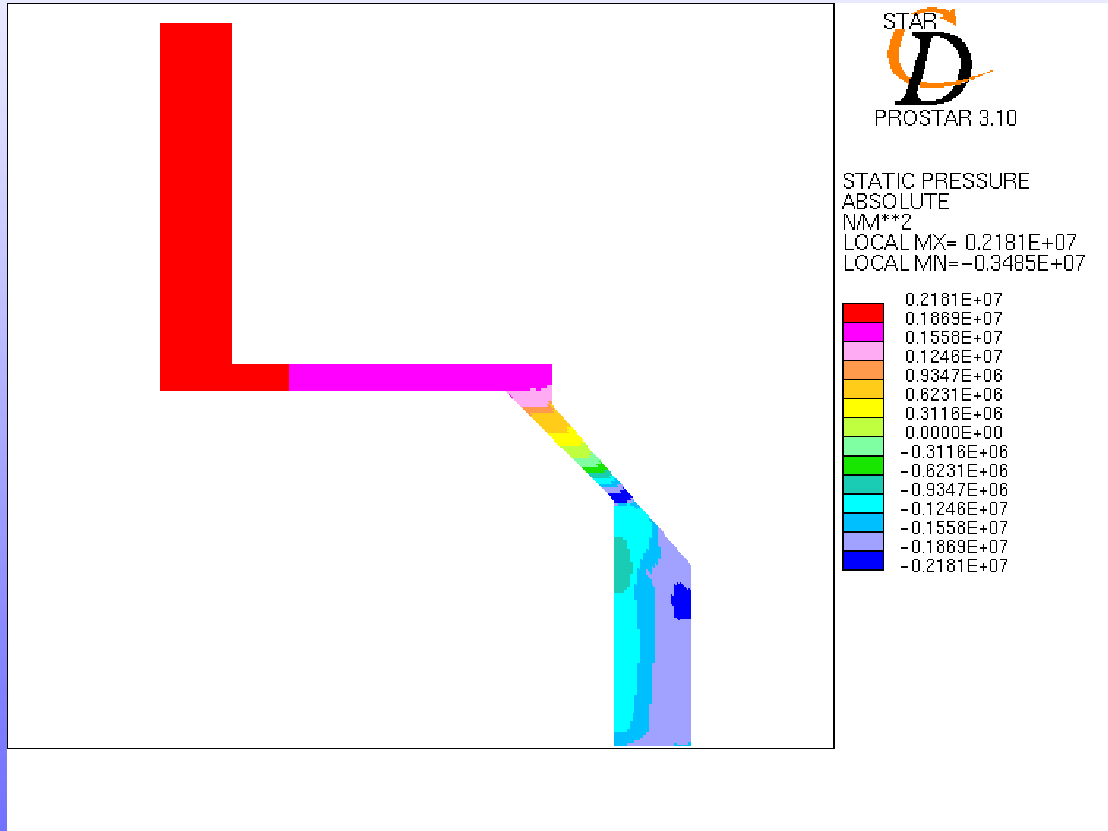
Autres travaux: **INJECTION D ’ ESSENCE**

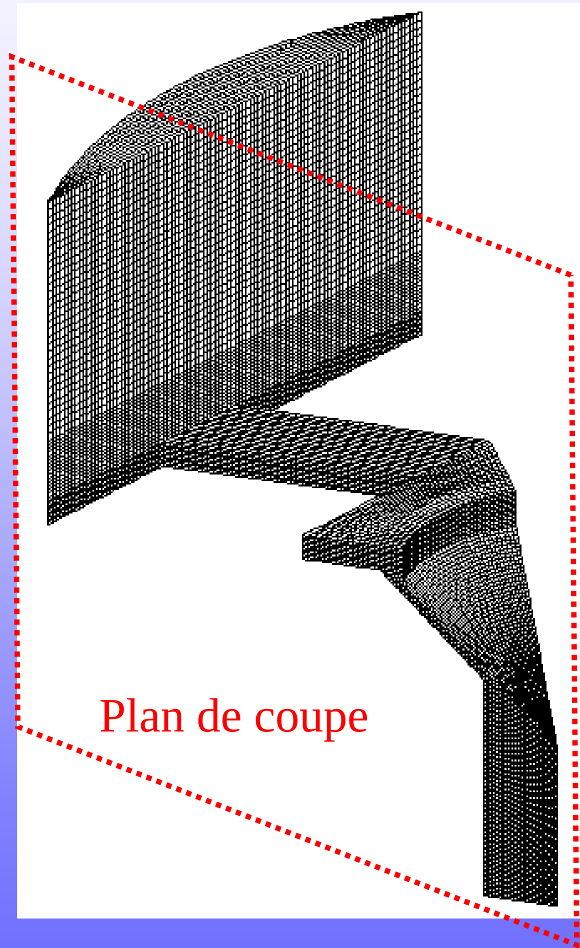




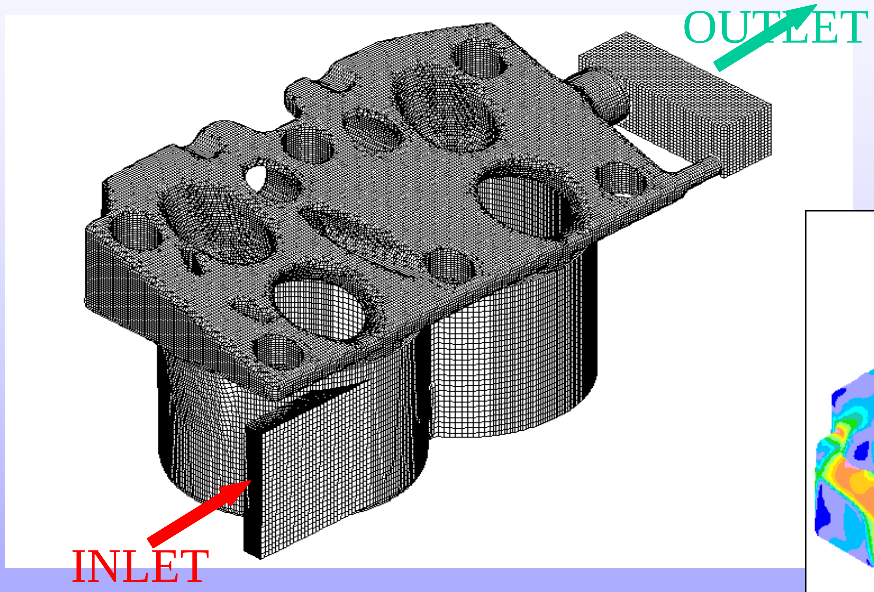
Autres travaux: INJECTION D ’ ESSENCE

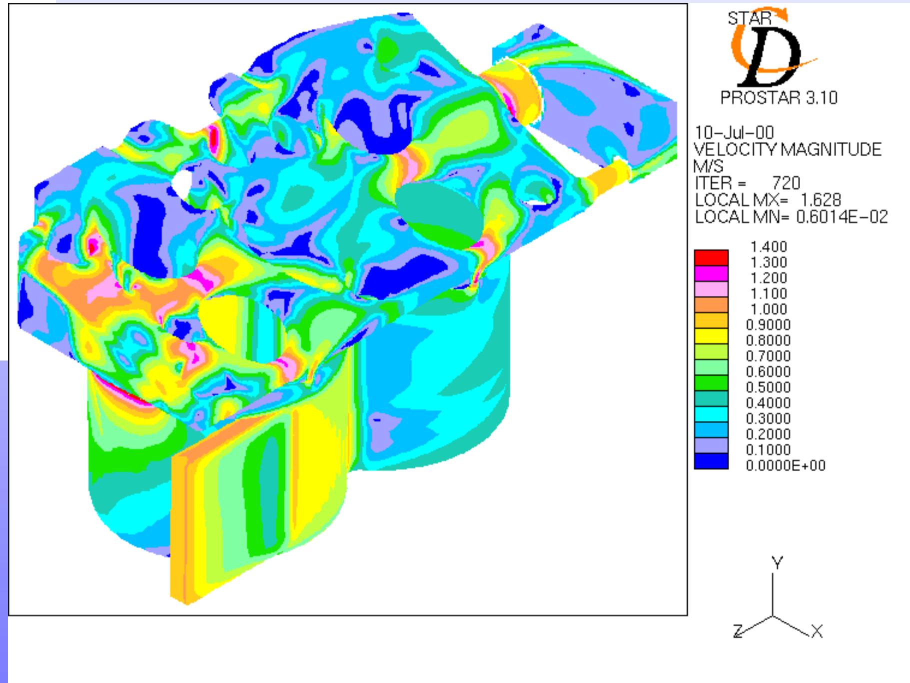
-> Nécessité de modéliser la cavitation





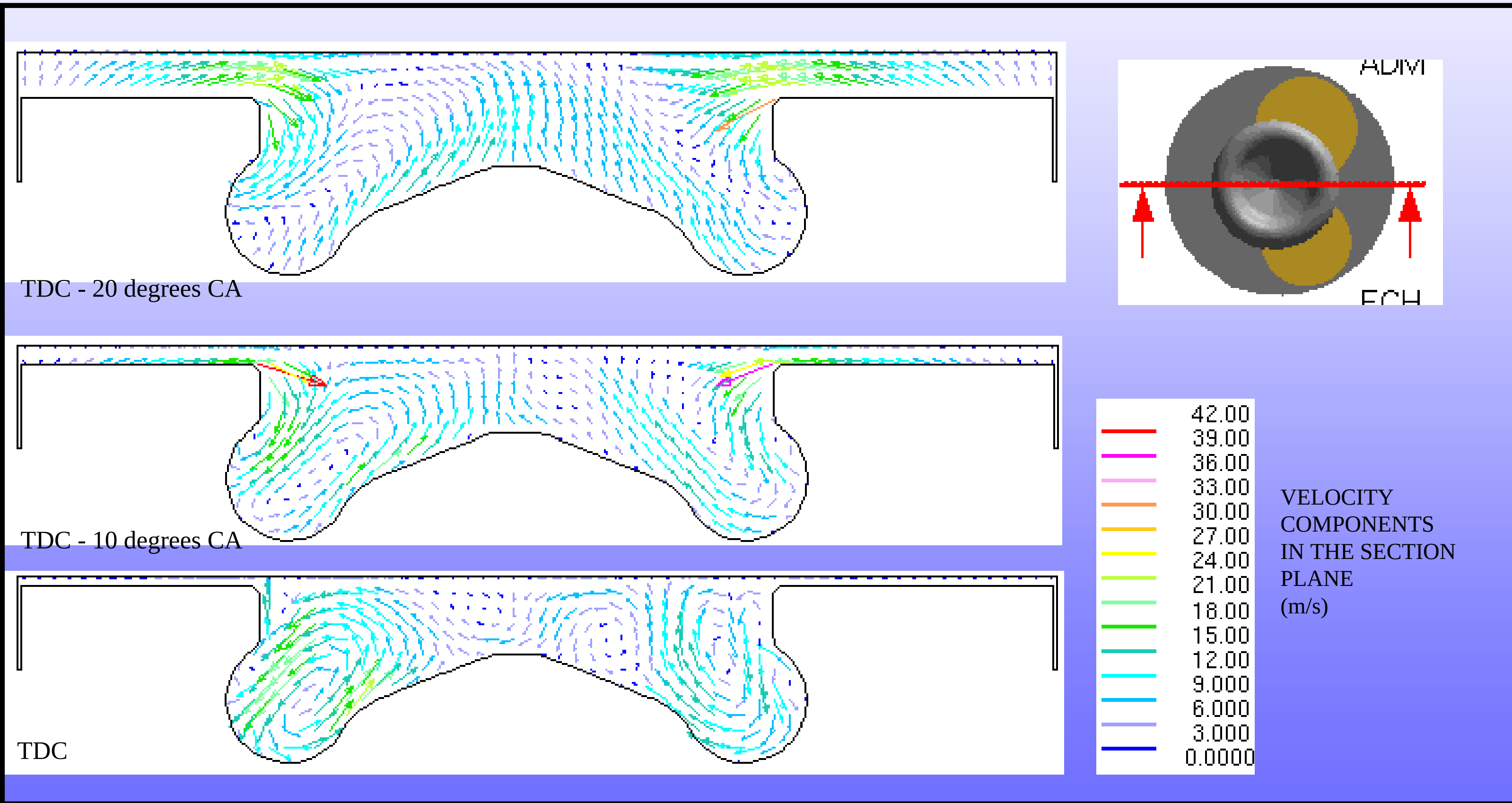
Autres travaux: **Refroidissement**





Autres travaux:

AERODYNAMIQUE INTERNE DANS LE CYLINDRE D ’UN MOTEUR DIESEL AVEC BOL DE COMBUSTION



Autres travaux: Calcul d'E.G.R. en instationnaire: