Assessing Port Design Effects Using 3D CFD Tool

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- Port Design and Optimization using 3D CFD
  - Low Speed Part Load
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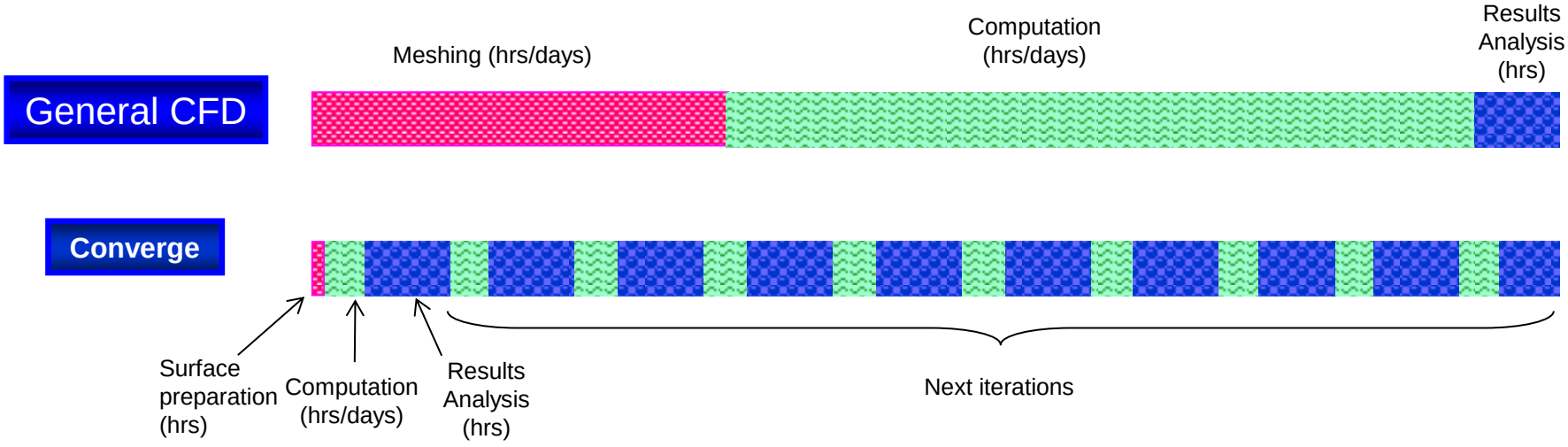
Background – benefit of zero-meshing

Speed up benefits:



Example of Modeling Validation

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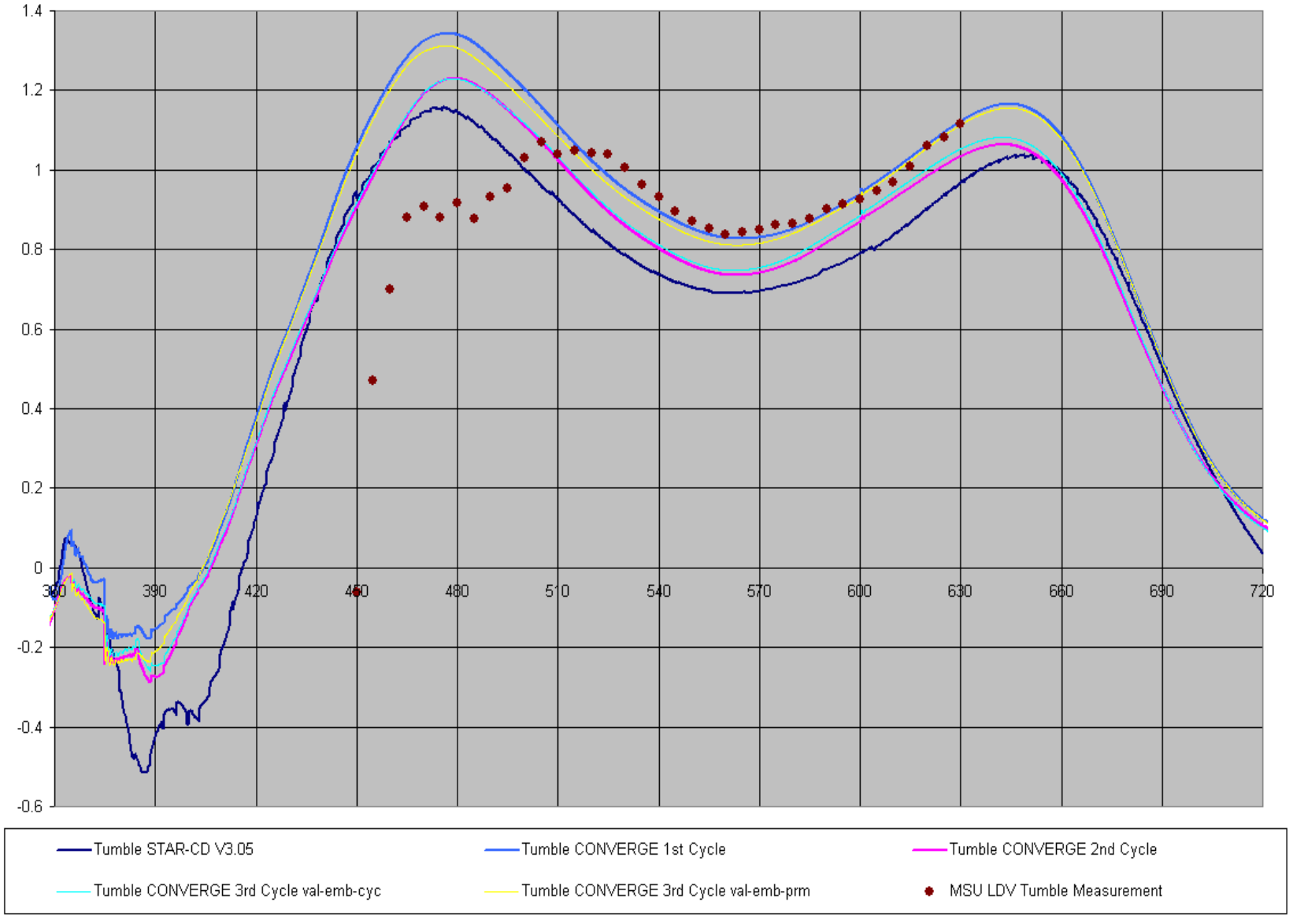
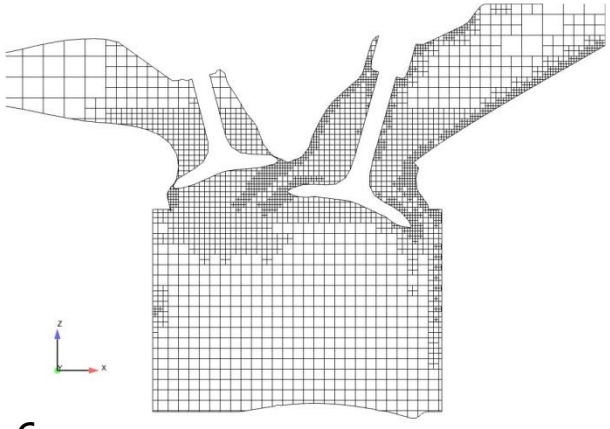
- 

Engine Configuration and Meshing Strategy

3.5L Engine Configuration:

Bore	92.5mm
Stroke	86.7mm
Squish Height	1.2mm
Compression Ratio	10:1



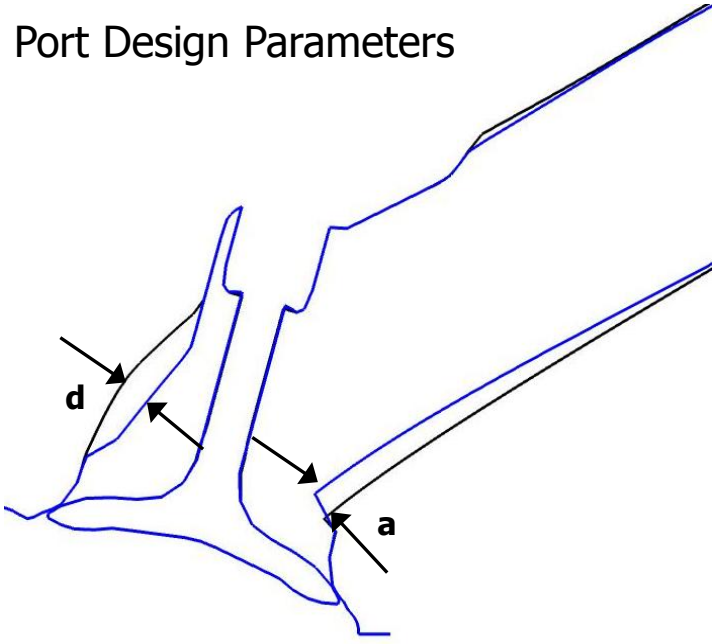
Embedding:

- Base grid: 6mm
- Embedding: Chamber & Valve seats
- Velocity and Temperature AMR

Assessing:

1. Low Speed Part Load,
2. Mid Speed High Load &
3. High Speed High Load.

Port Design Parameters



Effects of design parameters 'a' and 'd' on tumble ratio (TR) and turbulence intensity(U') at TDC, 1500rpm-2.62bar BMEP:

Port Iteration	a(mm)	d(mm)	TR@ BDC	U'@TDC (m/s)
XO Port	-	-	0.63	1.41
Port 5	3.3	4	0.73	1.37

Port 5: Mask effects

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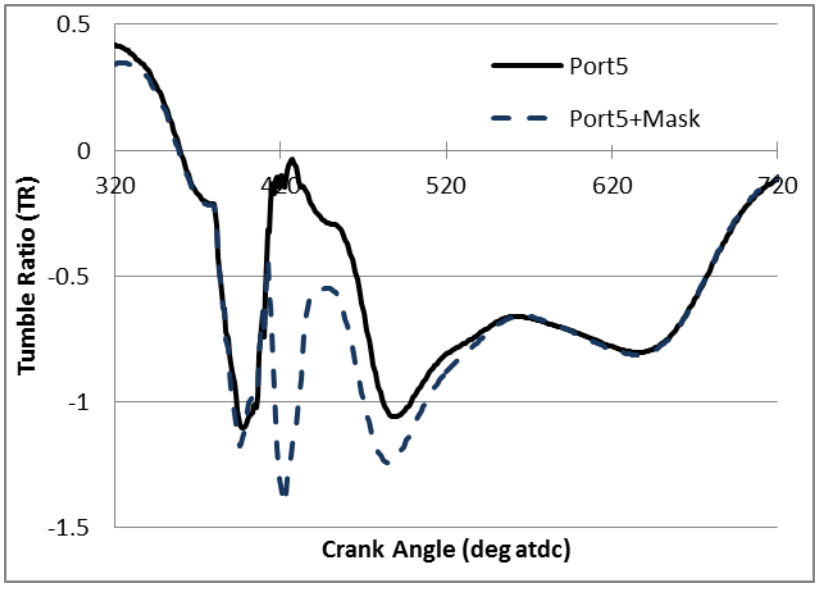
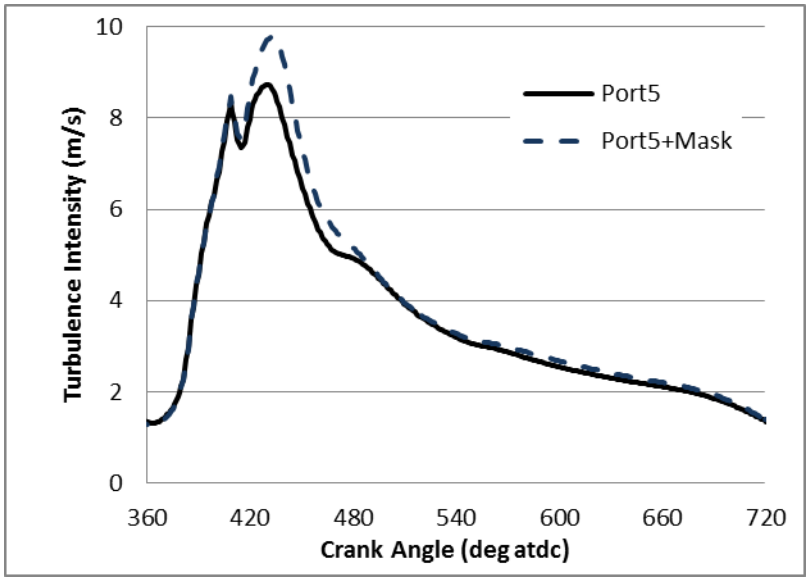
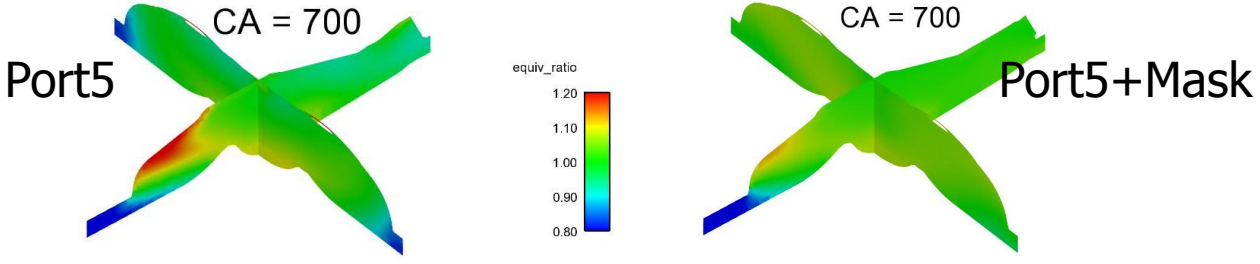
Low Speed Part Load







Port iteration	TR @BDC	U'@TDC(m/s)
Port 5	0.73	1.37
Port 5 + Mask	0.75	1.41

High tumble ports effects

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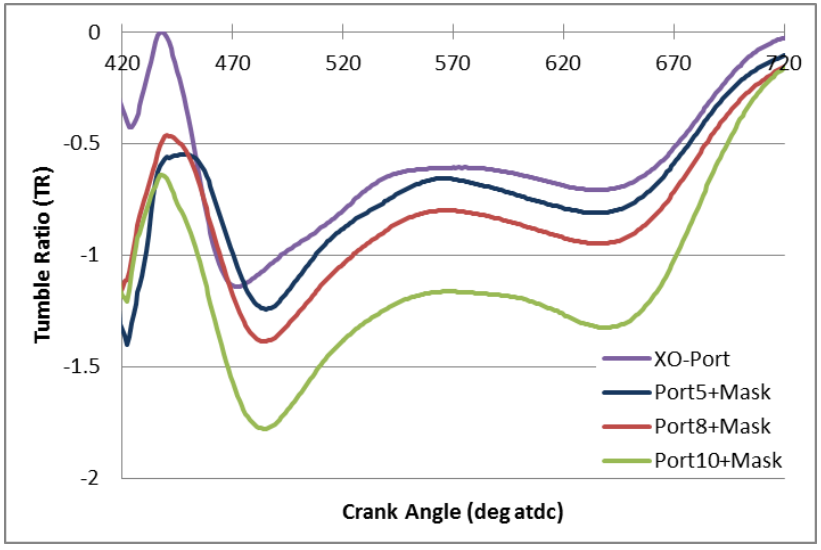
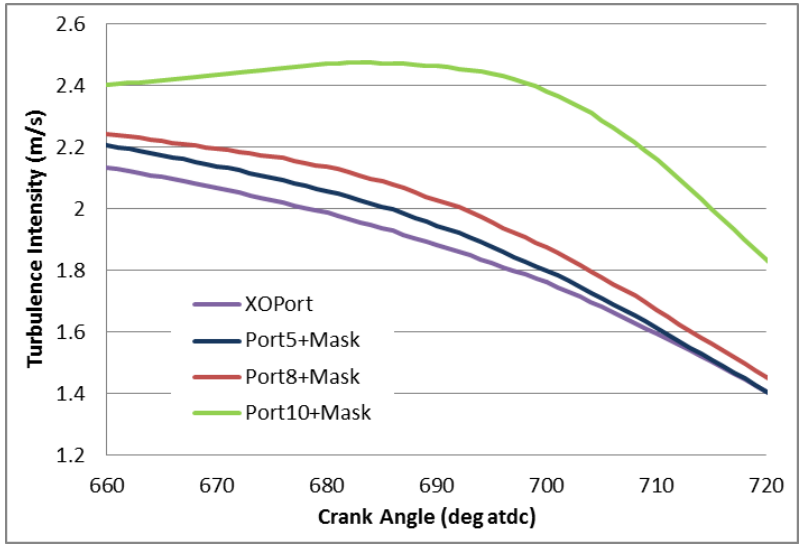
Low Speed Part Load





Port iteration	TR @BDC	U'@TDC(m/s)
XO Port	0.65	1.41
Port 5 + Mask	0.75	1.41
Port 8 + Mask	0.89	1.46
Port 10 + Mask	1.24	1.83

A/F Mixing Uniformity

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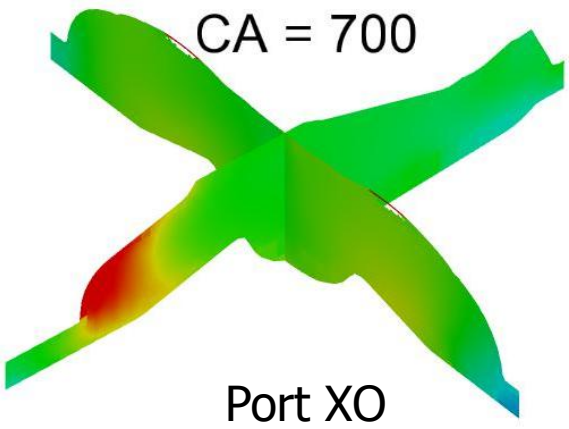
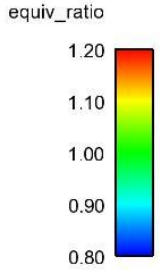
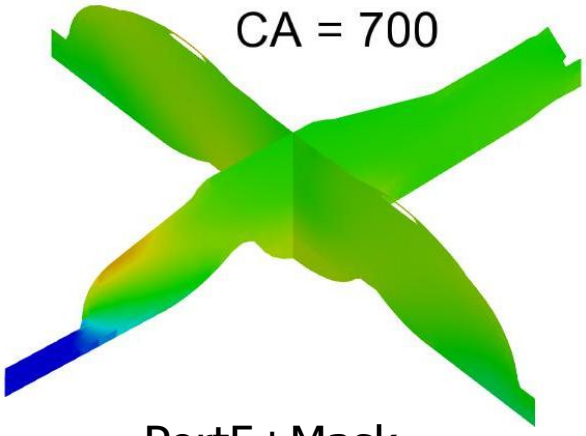
Low Speed Part Load

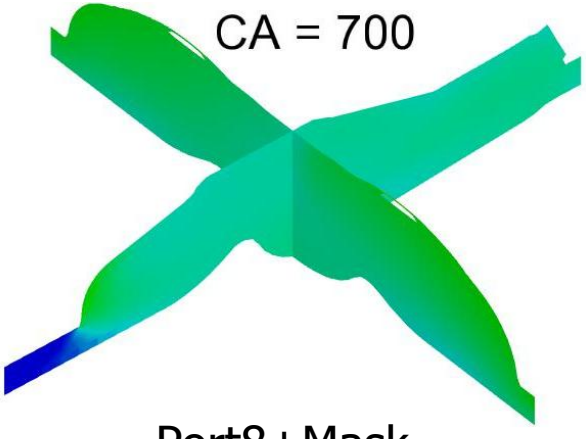


Port XO

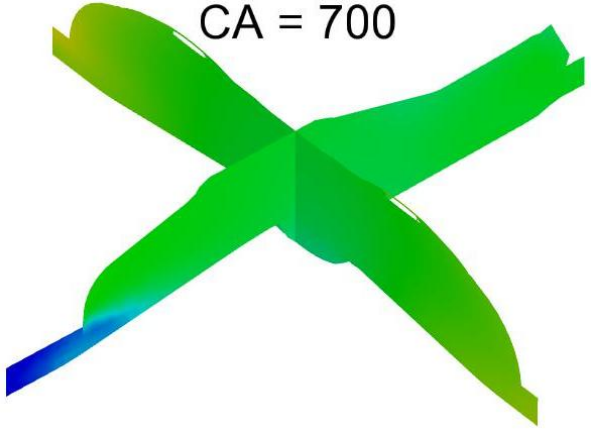




Port5+Mask



Port8+Mask



Port10+Mask

Velocity Flow Fields

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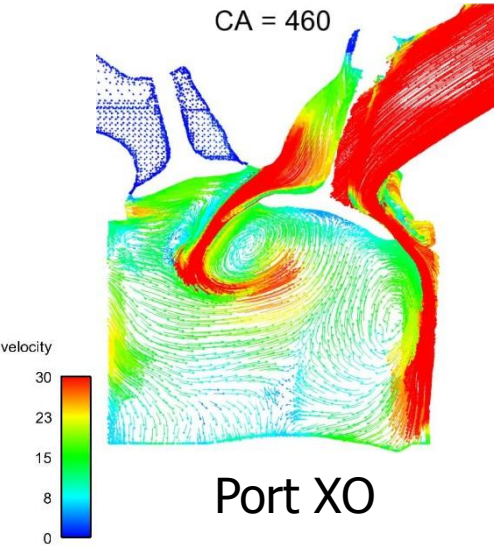
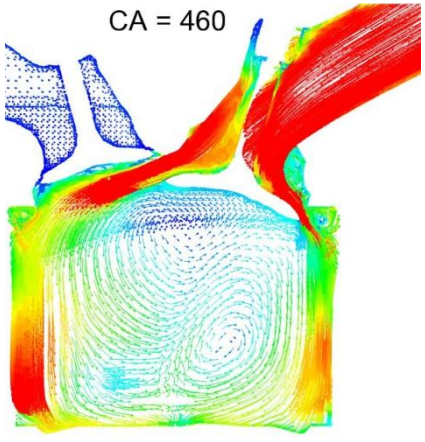
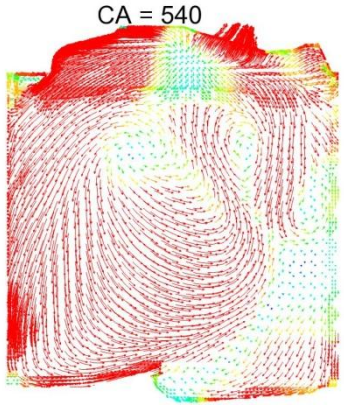
Low Speed Part Load



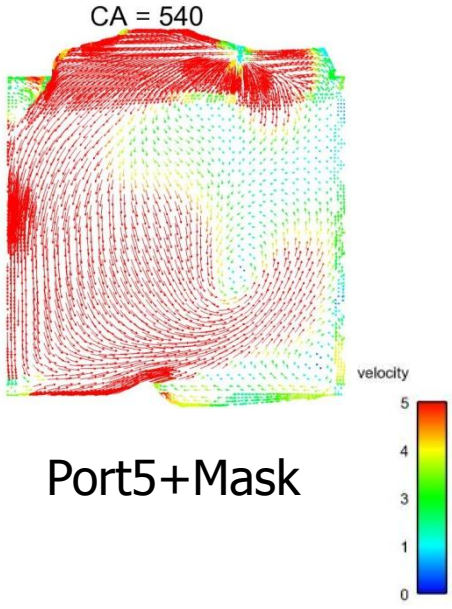
Port XO



Port5+Mask



Port XO



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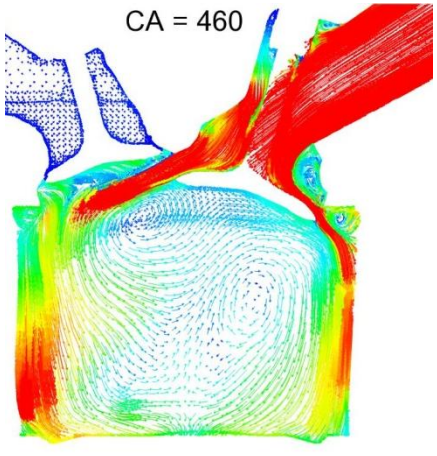
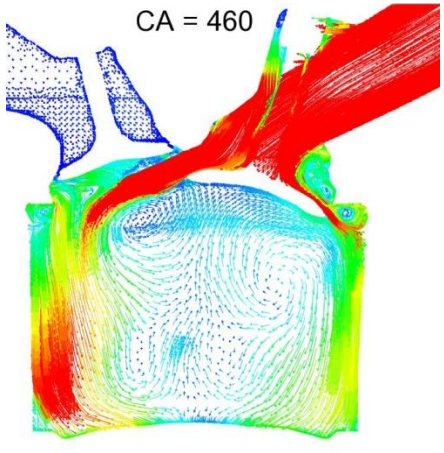
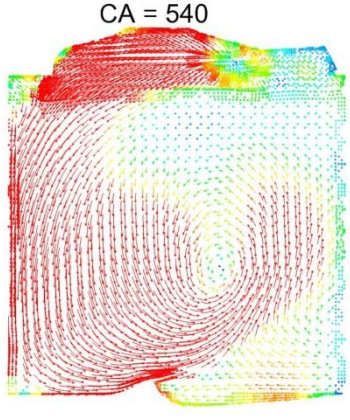


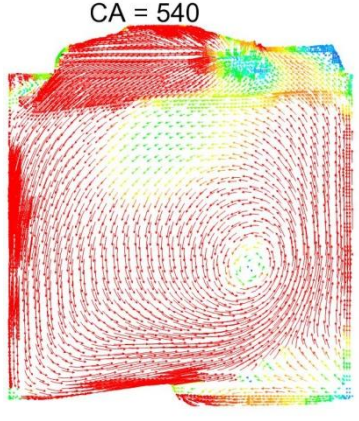
Port8+Mask



Port10+Mask



Port8+Mask



Port10+Mask

Port 5: Mask effects

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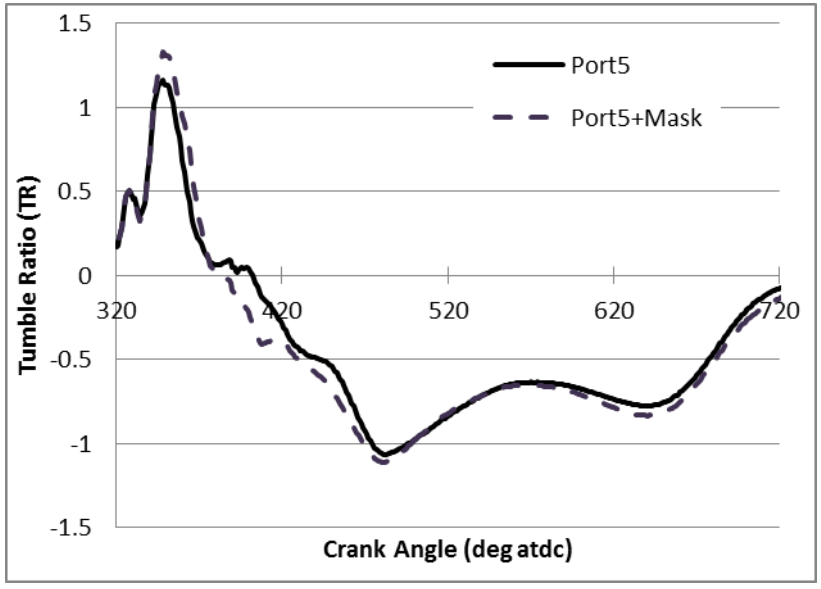
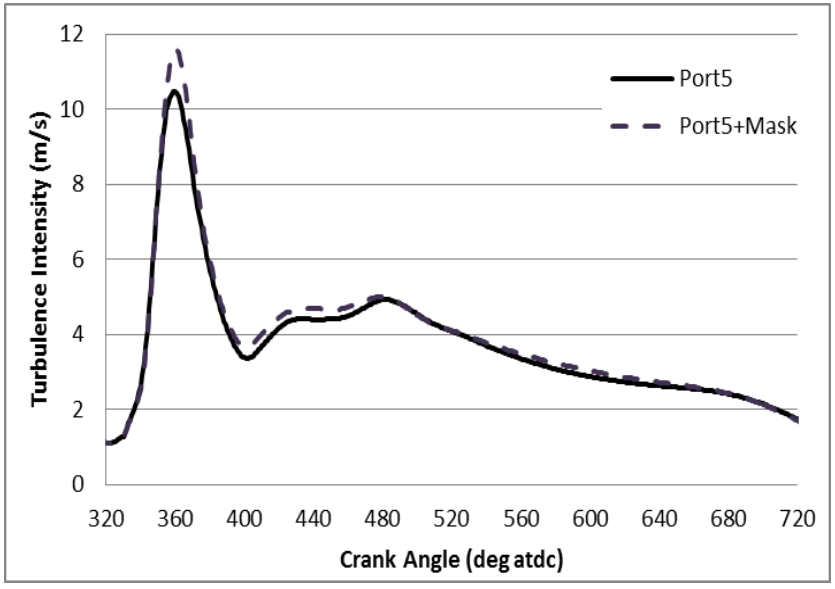
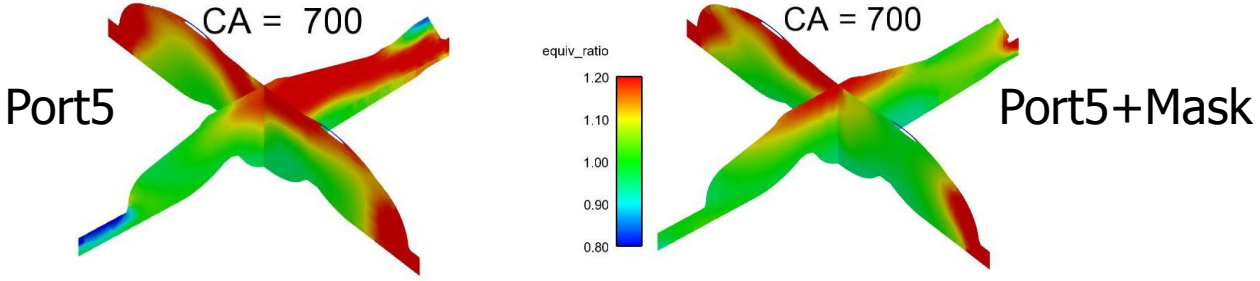
Mid Speed High Load







Port iteration	TR @BDC	U'@TDC(m/s)
Port 5	0.72	1.75
Port 5 + Mask	0.73	1.77

High tumble ports effects

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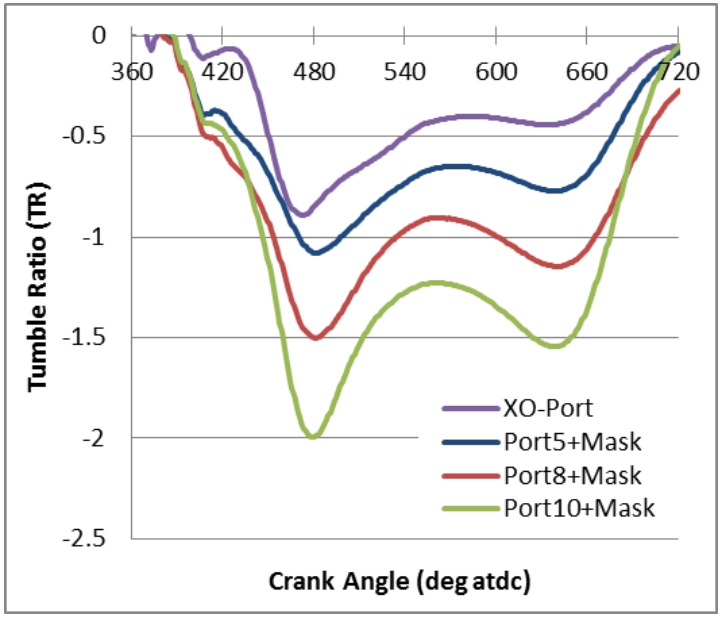
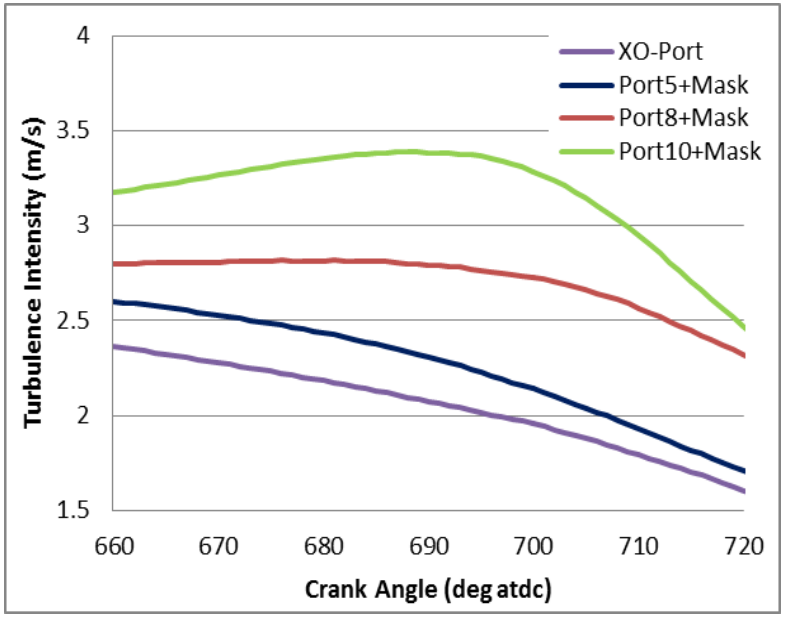
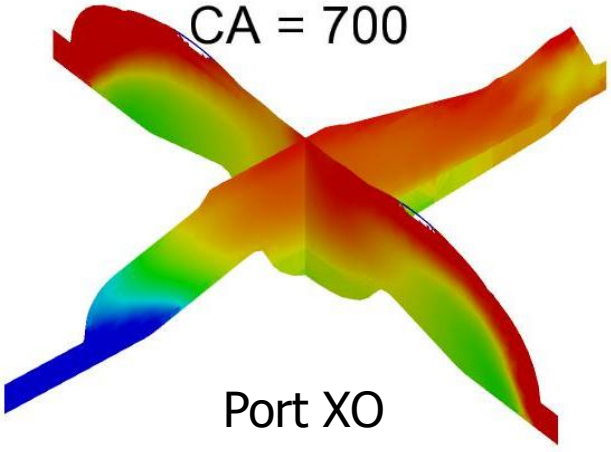
Mid Speed High Load



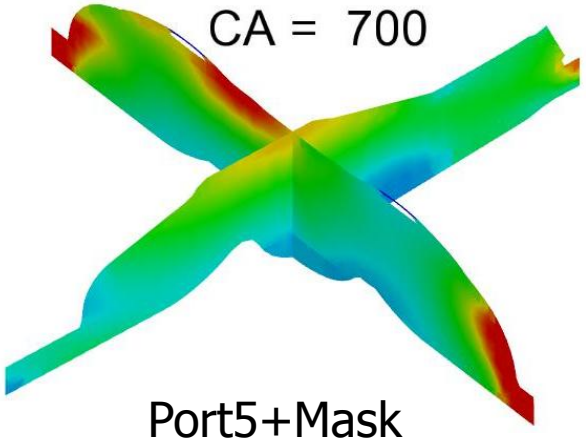


Port iteration	TR @BDC	U'@TDC(m/s)
XO Port	0.50	1.61
Port 5 + Mask	0.73	1.77
Port 8 + Mask	0.97	2.32
Port 10 + Mask	1.28	2.47

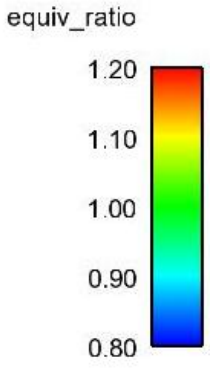
Mid Speed High Load

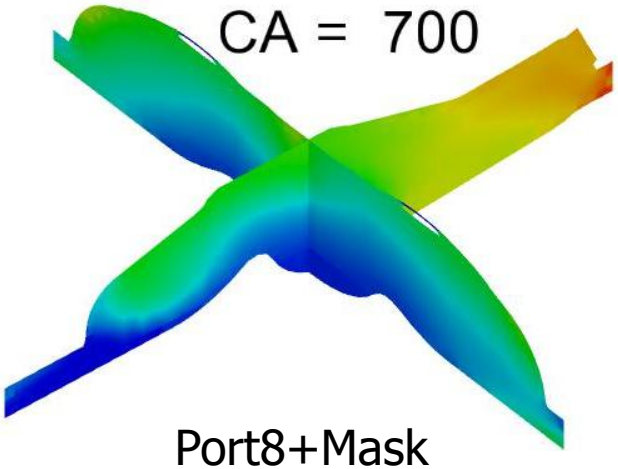


Port XO

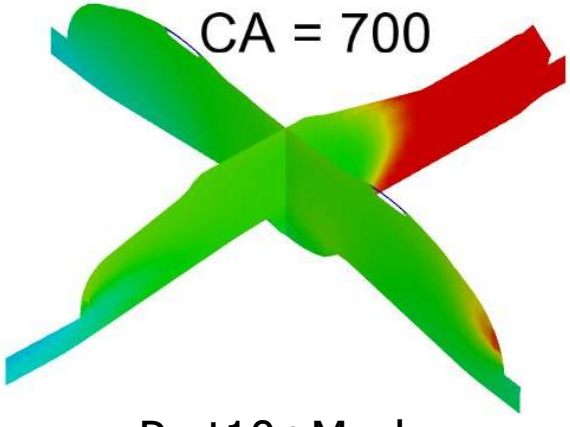


Port5+Mask





Port8+Mask



Port10+Mask

Velocity Flow Field Analysis

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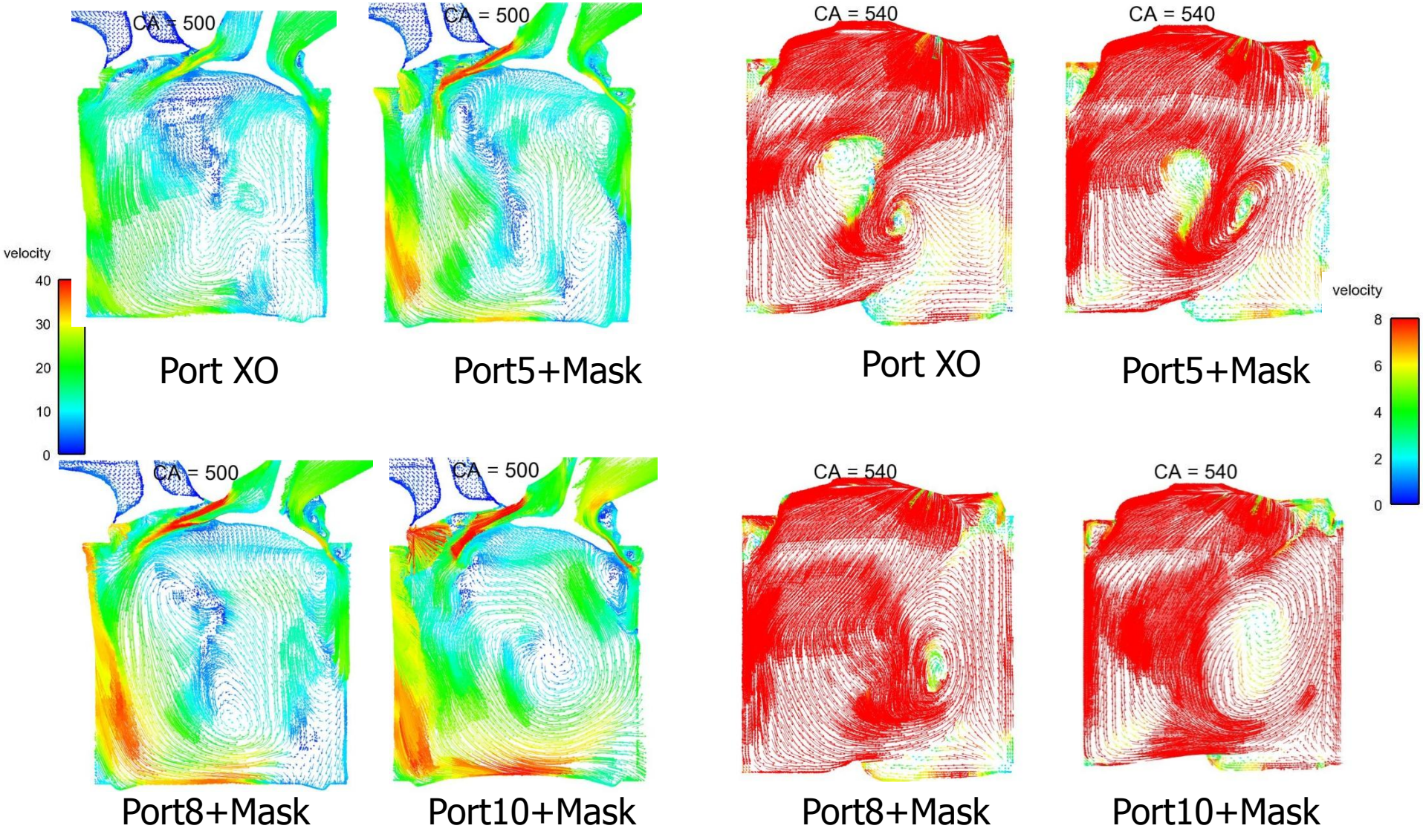
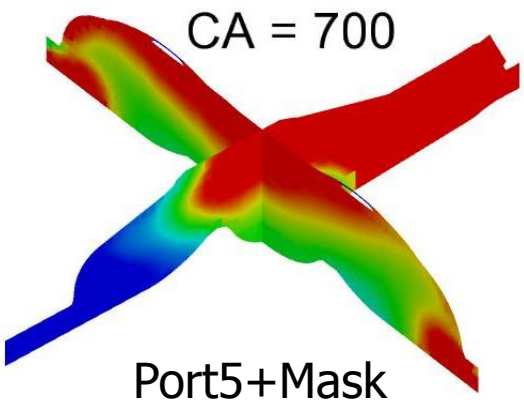
Mid Speed High Load

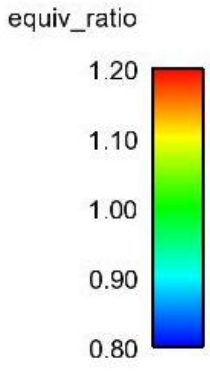


Single vs. Multiple Injections

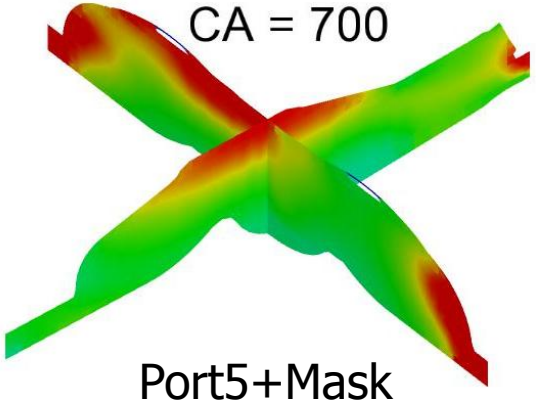
Mid Speed High Load

SOI=420





SOI=400 & 500



- Multiple injections help the a/f mixing

Port 5: Mask effects

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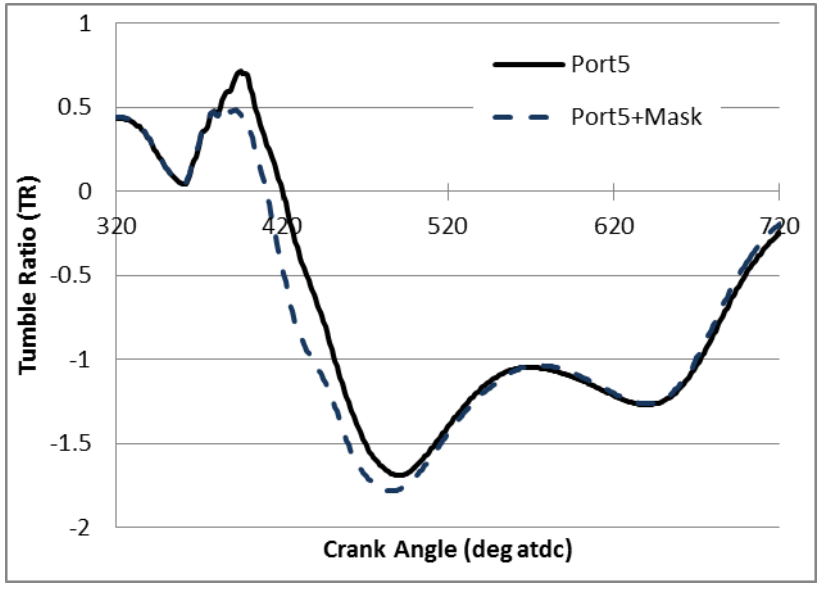
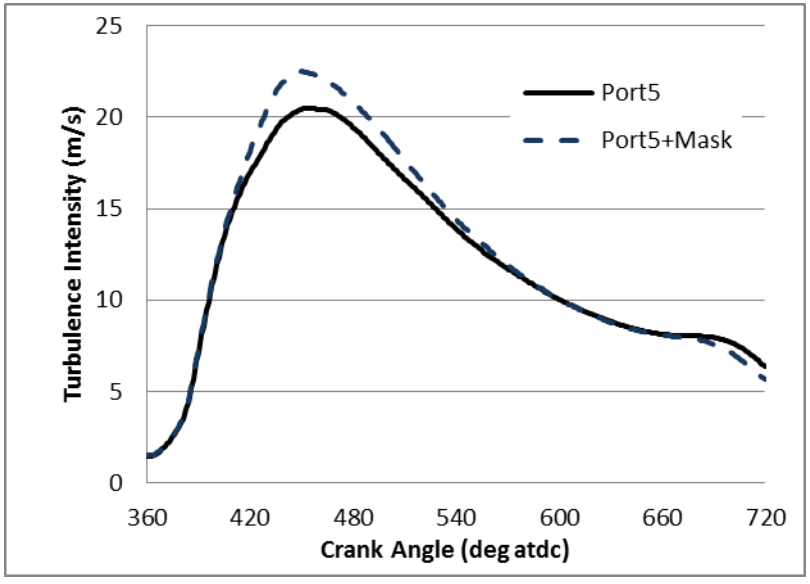
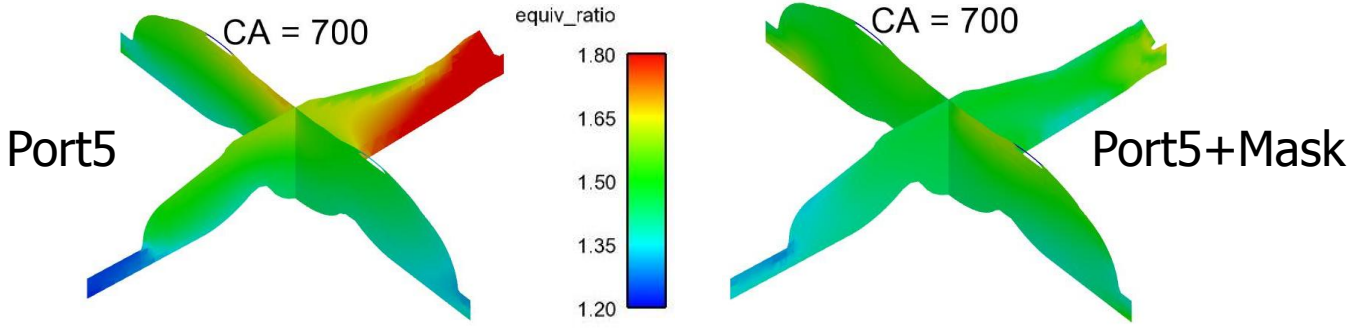
High Speed High Load





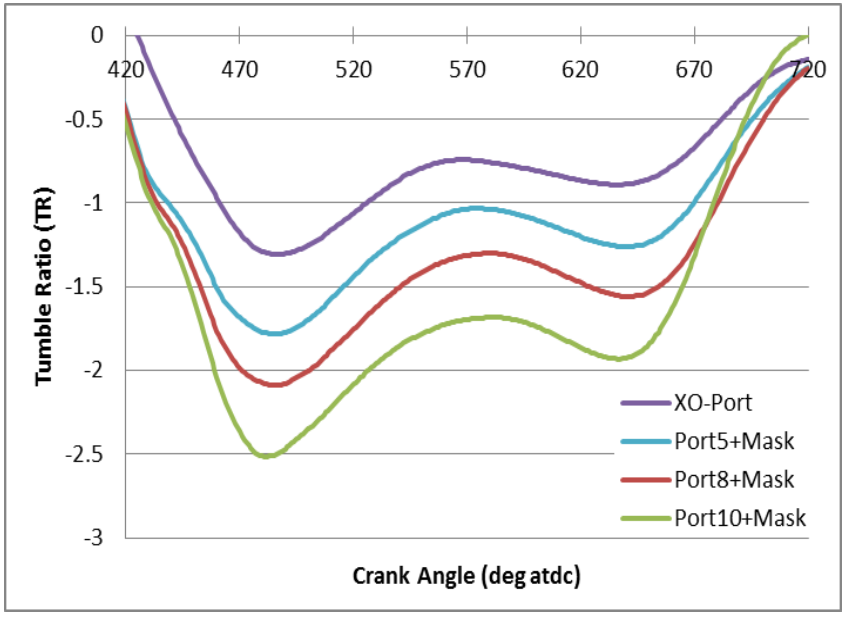


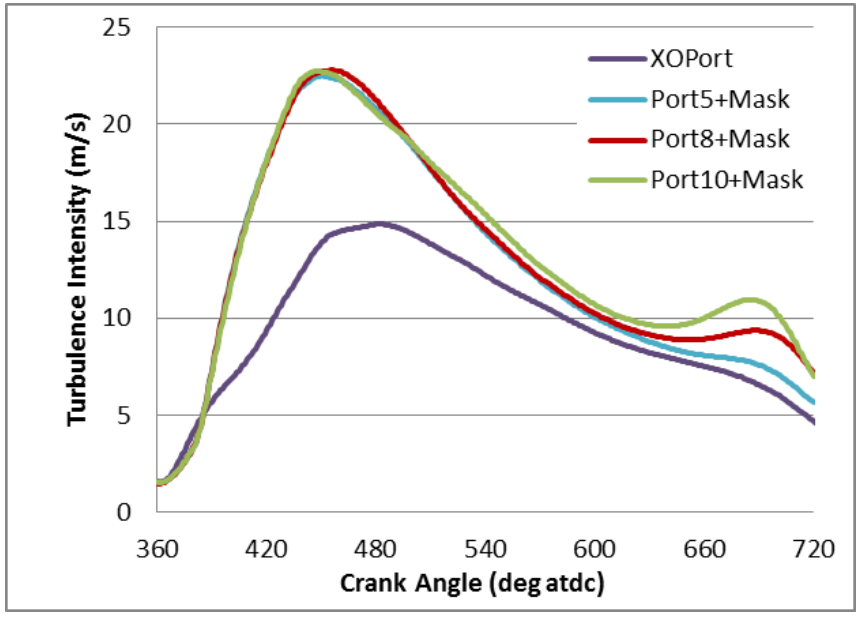
Port iteration	TR @BDC	U'@TDC(m/s)
Port 5	1.17	6.37
Port 5 + Mask	1.21	7.14

High tumble ports effects

Research and Advanced Engineering

High Speed High Load





Port iteration	TR @BDC	U'@TDC(m/s)
XO Port	0.86	4.70
Port 5 + Mask	1.21	7.14
Port 8 + Mask	1.50	7.17
Port 10 + Mask	1.86	7.01

Air-Fuel Mixing Uniformity

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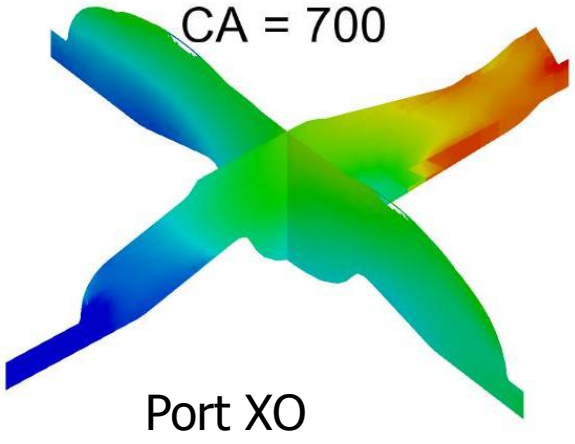
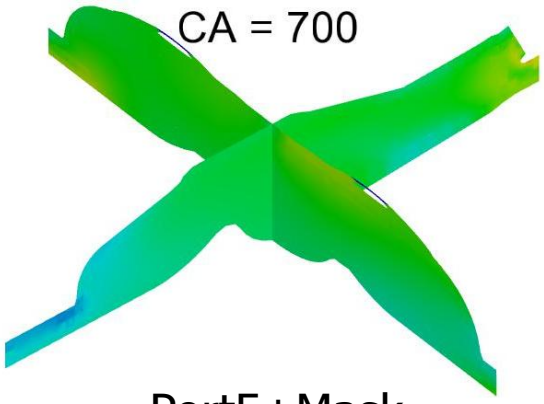
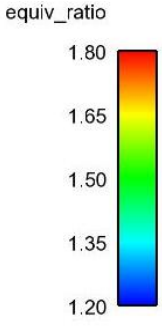
High Speed High Load

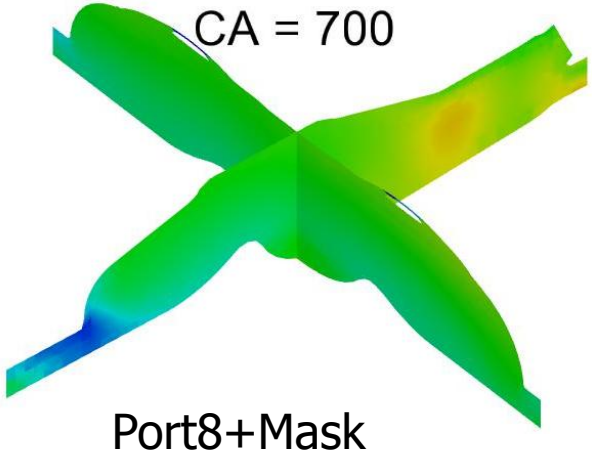


Port XO

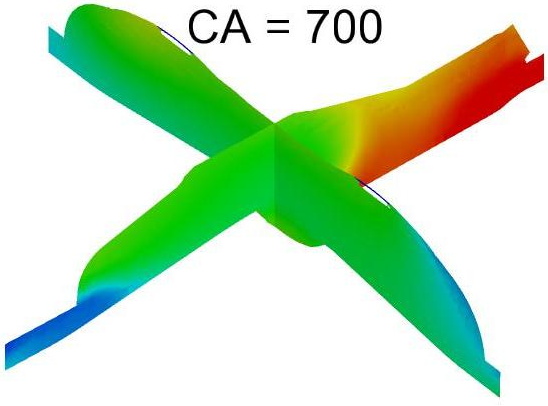


Port5+Mask





Port8+Mask

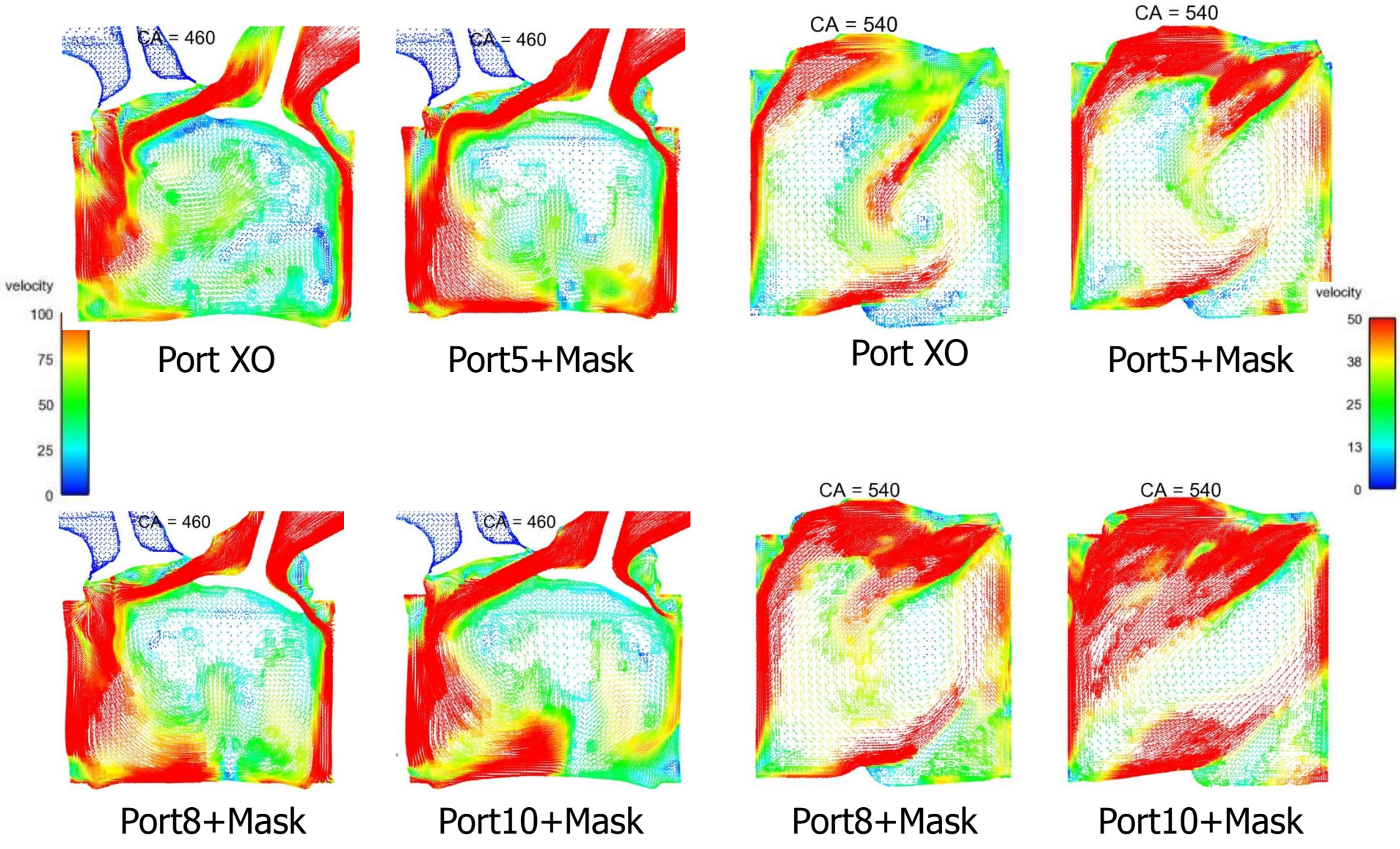


Port10+Mask

Velocity Flow Field

Research and Advanced Engineering

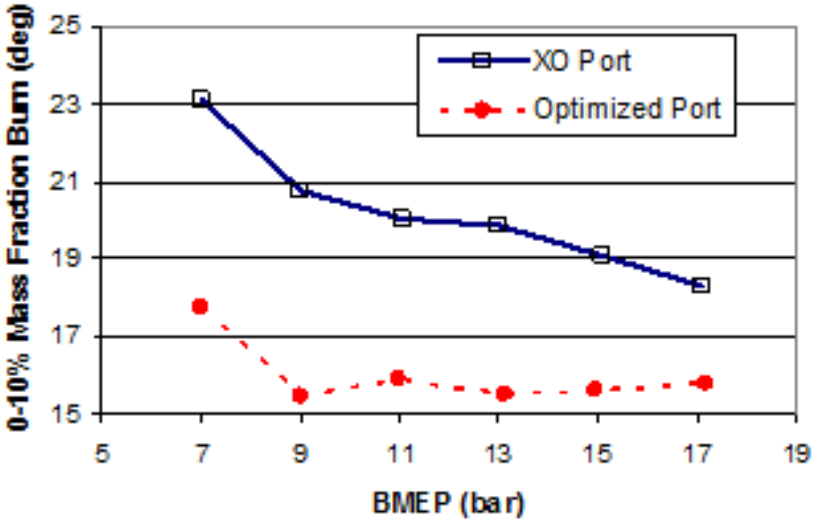
High Speed High Load

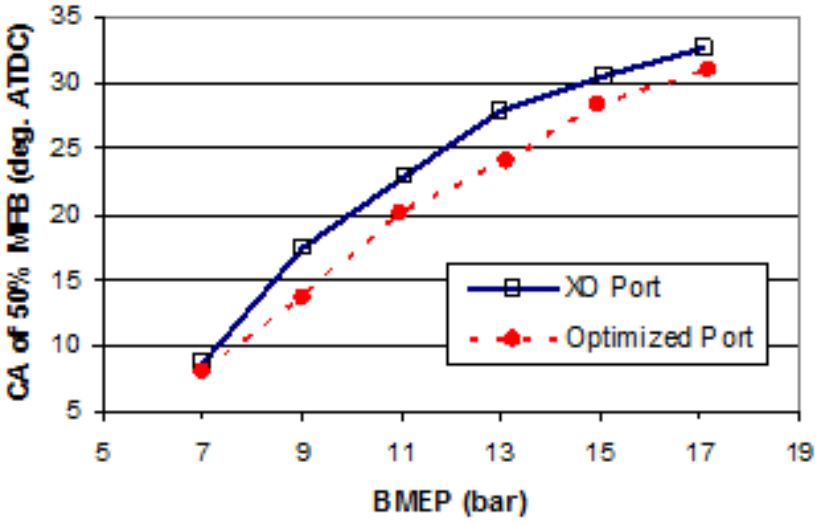


Port XO | Port5+Mask | Port XO | Port5+Mask

Port8+Mask | Port10+Mask | Port8+Mask | Port10+Mask

Dyno Measurement





- The dyno data shown is a load sweep at 1500 rpm.
- The dyno measurement confirmed the upfront optimization simulation results.
- The dyno data shows improvement in burn rates and knock resistance for the optimized port.

Summary

Research and Advanced Engineering

- 3D CFD simulation has been utilized in optimizing the intake port.
- The integrated CFD code has improved the turn around time of the 3D CFD simulation and enabled more engineering work in a shorter time.
- Dyno measurement confirmed the upfront optimization direction.