Development in conjunction with Department of Energy "Light Truck Diesel Program"

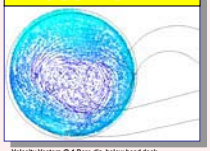
Analysis Led Intake Port Development

Analysis Led

Traditional

Baseline & Benchmark

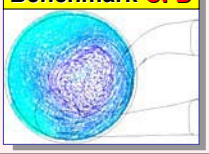
Baseline CFD



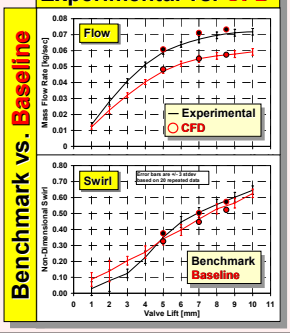
Velocity Vectors @ 1 Bore dia. below head deck

- Where do we stand against competition ?
- Need to improve?
- Match or exceed the best known performers
- Calibrate CFD to Experimental data

Benchmark CFD



Experimental vs. CFD



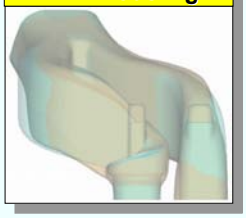
Flow Bench

Courtesy of Ricardo Inc.

- Know measurement capability of Flow Bench
- Does data repeat?

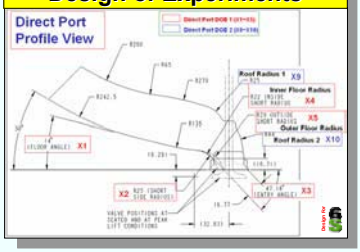
Design & Analysis

CAD Modeling



- Fully parametric CAD model
- Manufacturing factored in up front (draft, etc.)
- Same model used for CFD and hardware
- Ability to adjust the model for future changes

Design of Experiments



- CAD model enables multiple factor DOE
- Be smart about what's behind "Black Art"

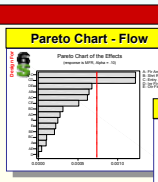
Grind & …

… Iterate

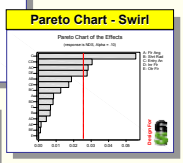
- Reliance on experienced technician ("Black Art")
- Non-optimized design
- Possible extensive amount of time involved (Time = $)
- Difficulties achieving consistency in port-to-port performance

Optimize & Finalize Design

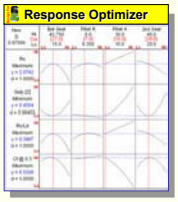
Pareto Chart - Flow



Pareto Chart - Swirl

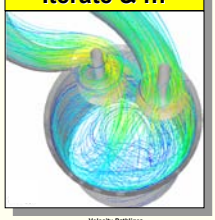


Response Optimizer



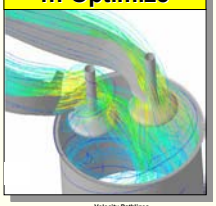
- What geometry factors have most effect?
- Understand the interaction between various factors
- Come up with a few optimal designs for flow box validation

Iterate & …



Velocity Pathlines

… Optimize



Velocity Pathlines

Reverse Engineering

Point cloud data from X-Ray Scanning

- Interpret technician's work into CAD model
- X-Ray, CT, Laser, or CMM scan to create non-parametric model
- Conversion to parametric model could add significant time

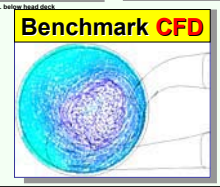
Verify & Procure Hardware

Final Design CFD

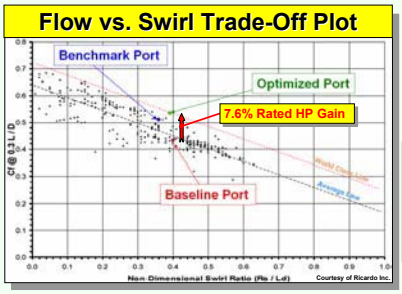
Velocity Vectors @ 1 Bore dia. below head deck

- How does the final design compare against benchmark?
- Used CFD for both qualitative & quantitative flow field
- Plot the actual flow data on world wide database

Benchmark CFD



Flow vs. Swirl Trade-Off Plot



- Always validate the final design with Flow Box
- Procurement of hardware comes only after the final design was validated
- Verify the final design in castings as a final step

Head Casting

Verification

Courtesy of Ricardo Inc.

EVERY TIME. EVERY PORT.

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