



GT-SUITE USER CONFERENCE

October 9, 2006 at the Mercure Hotel, Frankfurt Airport, Germany.

Topic:

“acoustic 1D modeling and simulation of air intake systems“

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Topics



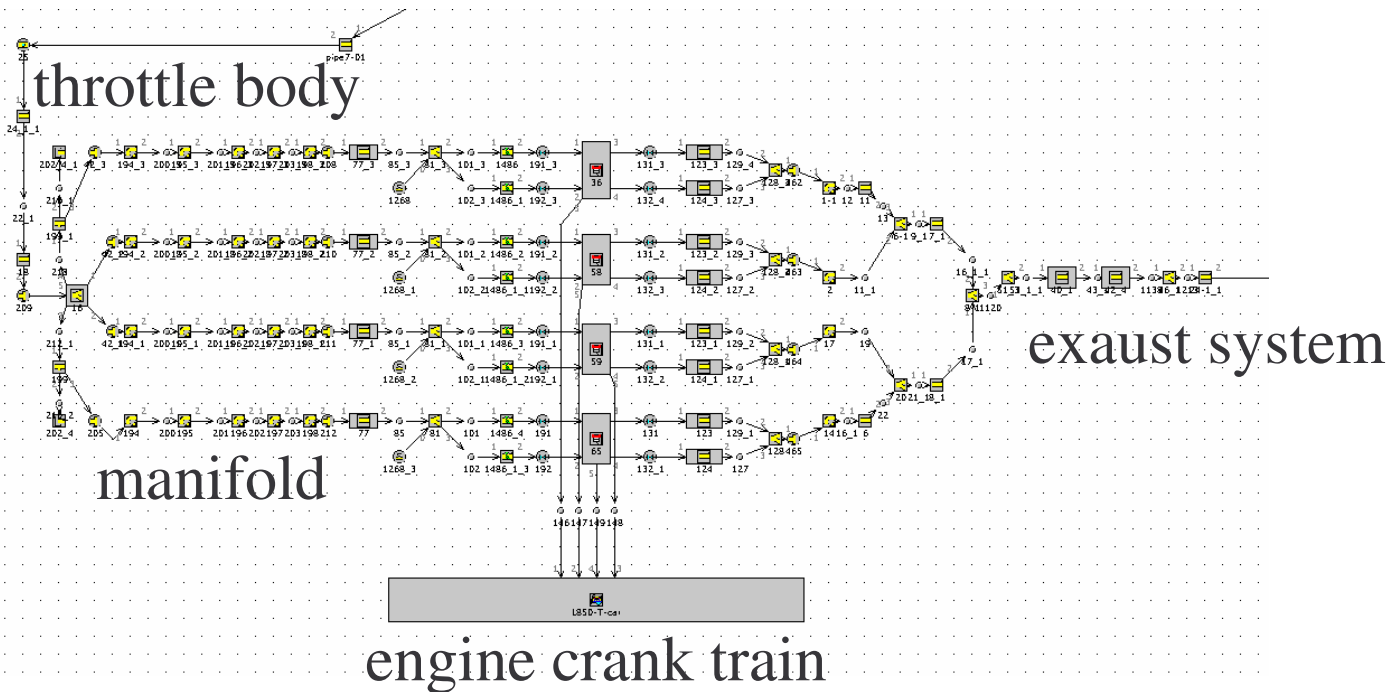
- Engine model preparation / validation
- STL data preprocessing of 3D volumes
- Set up of air intake system
- Transmission-Loss (TL) simulation
- OAL simulation
- GT-Results (Post processing and OAL analysis)
- Tuning steps
- Comparison simulation & measurement
- Conclusion

Engine model preparation / validation

- Case setup → 100rpm steps

missing intake system

throttle body



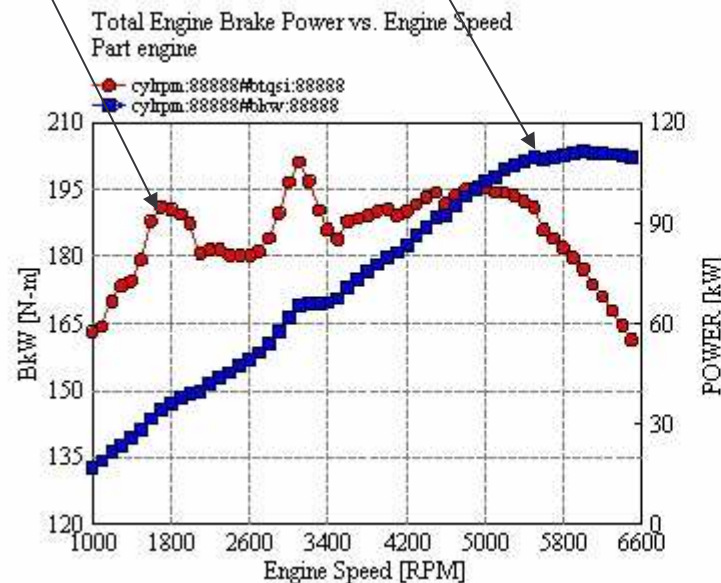
Engine model preparation / validation



- Case setup → 100rpm steps
- Validation of torque / power and Volef / BMEP data
- pressure indication

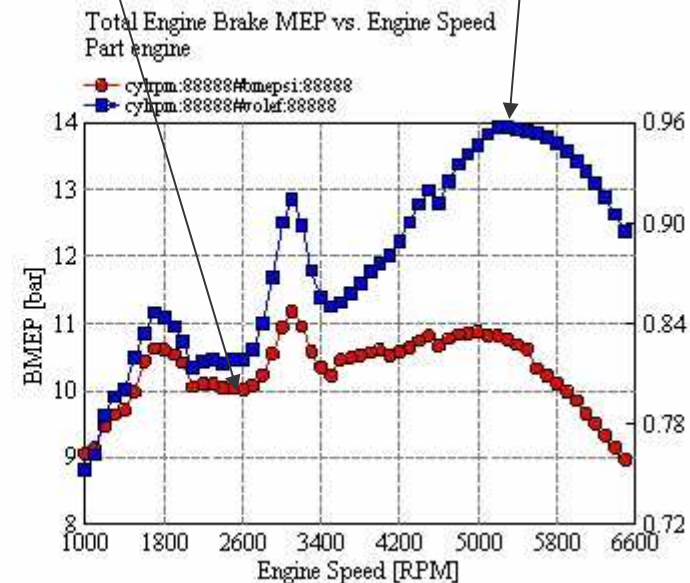
torque

power



BMEP

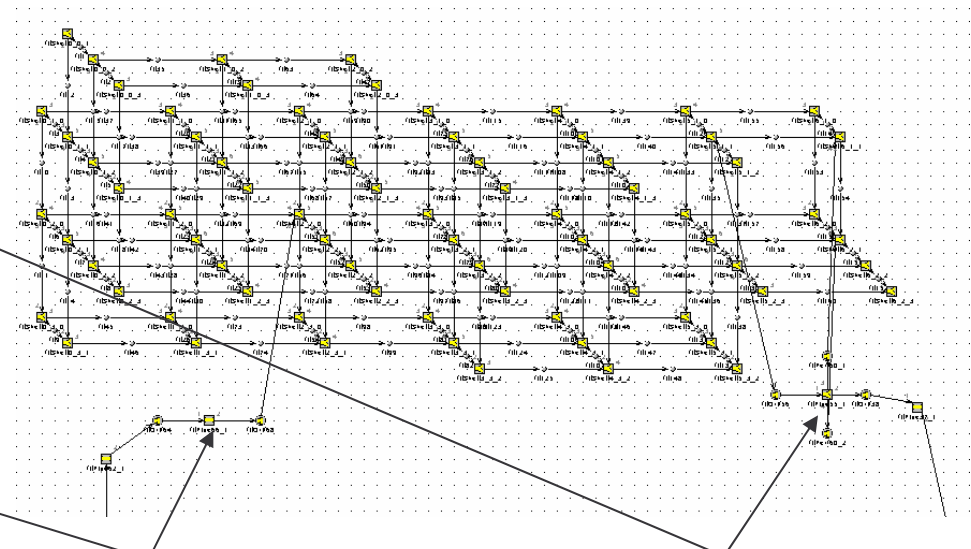
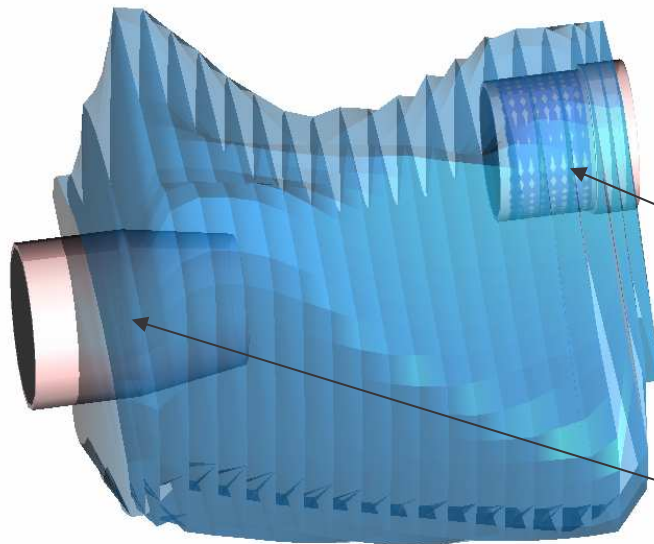
volef



STL data preprocessing of 3D volumes



- muffler imported STL-file
- CSD and DSD pipe



diffusor CSD

porous duct

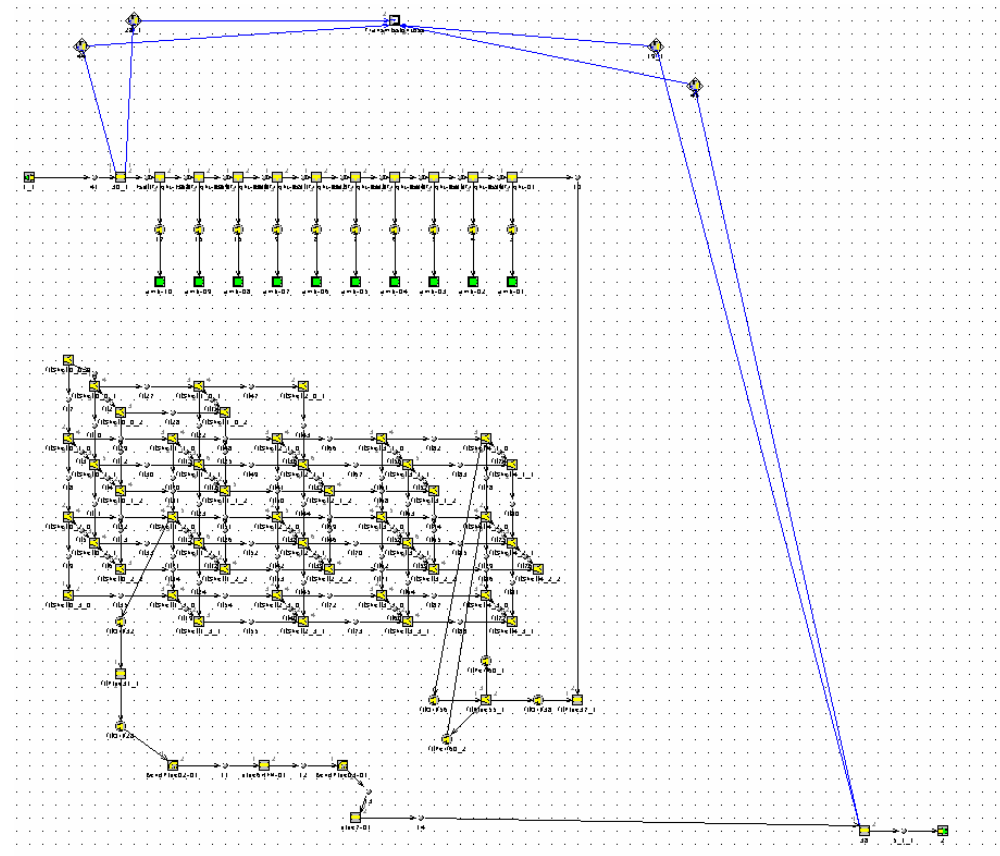
Set up of air intake system

- setup of TL analysis object
- porous duct
- air cleaner housing
- Clean Side Duct (CSD)

- TL measurement



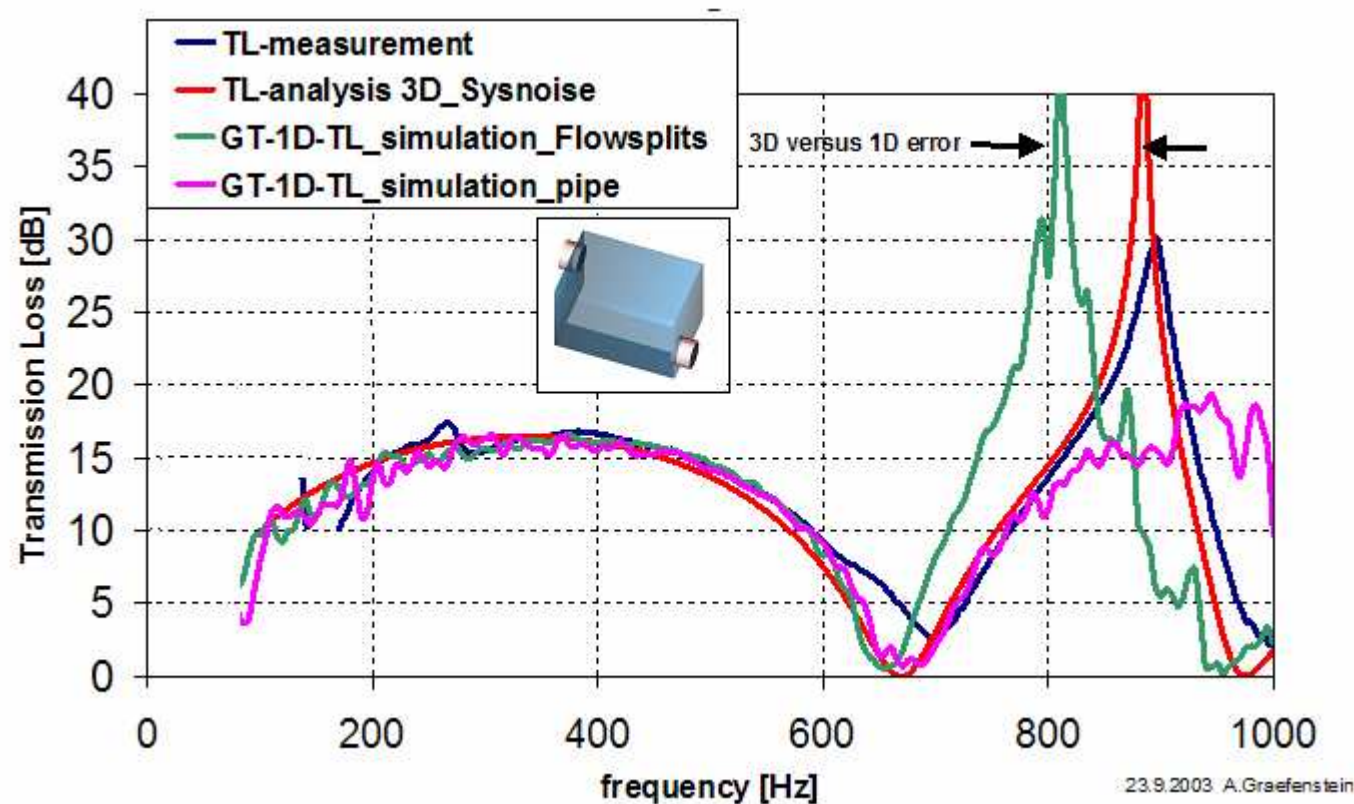
■ TL simulation



Set up of air intake system

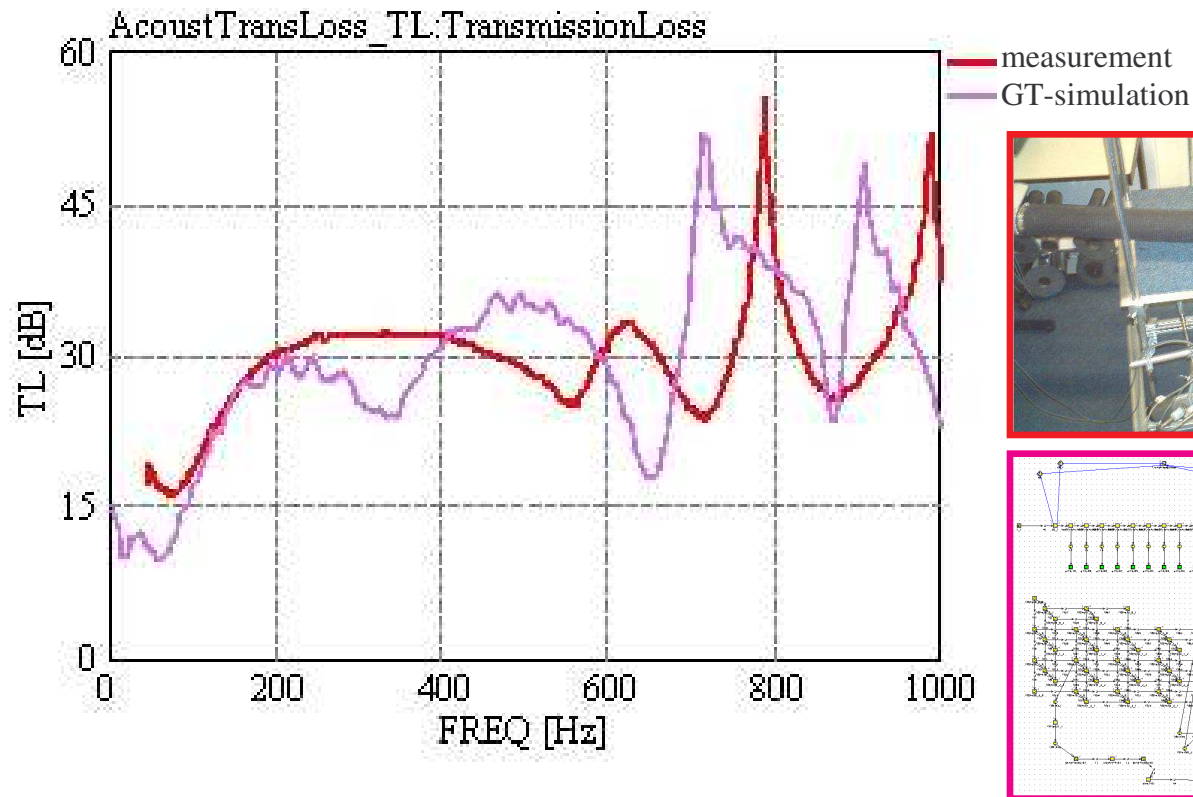


- simple geometry



Transmission-Loss (TL) simulation

- more complex geometry (muffler imported STL-file)

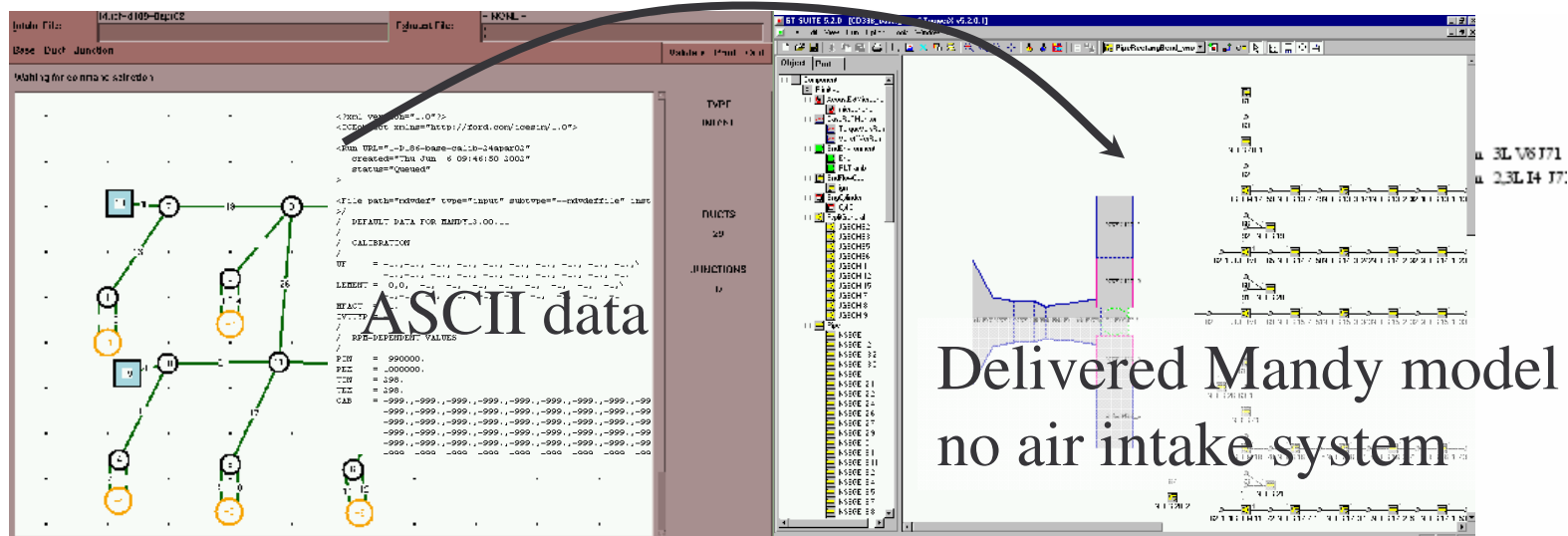


OAL simulation



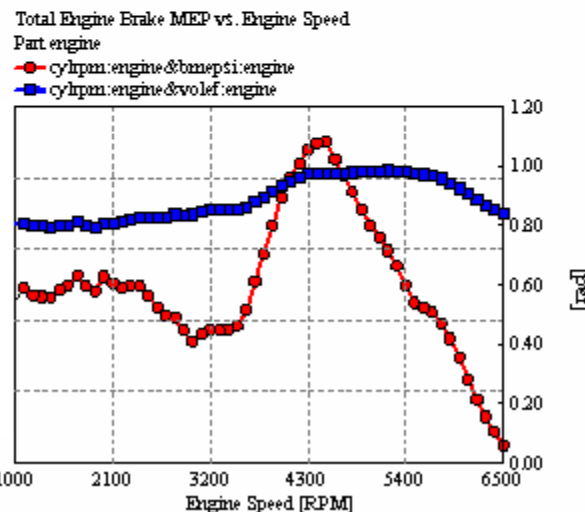
- engine run up setting
 - time control flag : periodic cycles
 - rpm steps : 100rpm
 - from 1000rpm to 6500rpm gasoline engines
 - from 1000rpm to 4500rpm diesel engines
- microphone setting
 - distant and angle according customer specification
 - windowing according custom specification
 - M&H standard : 100mm/45deg Hanning-windowing
- Postprocessing analysis
 - Order & Campbell analysis according customer specification
 - tracking of performing data as torque, brake mean power,

OAL simulation model conversion



Total
Part engine
GT-model not calibrated
Brake Mean Efficiency Pressure
& Vol. eff. have to be checked
Calibration to Mandy model
should be done

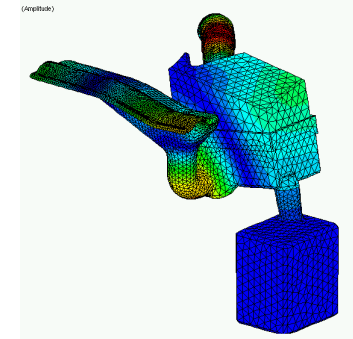
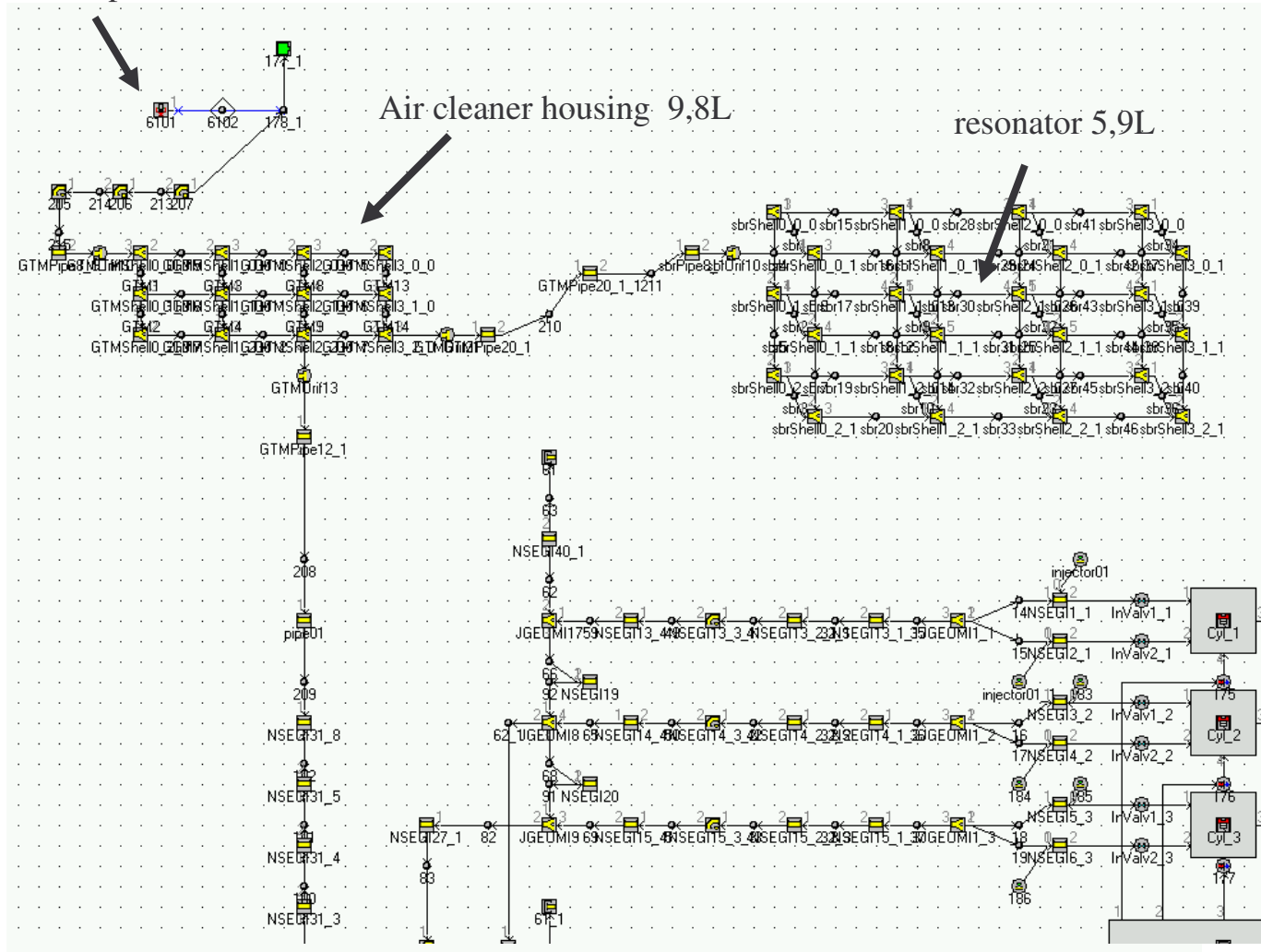
Engine Speed [RPM]



OAL simulation

Modelling the air intake system

Microphone



GT-results CD338_base01.gb

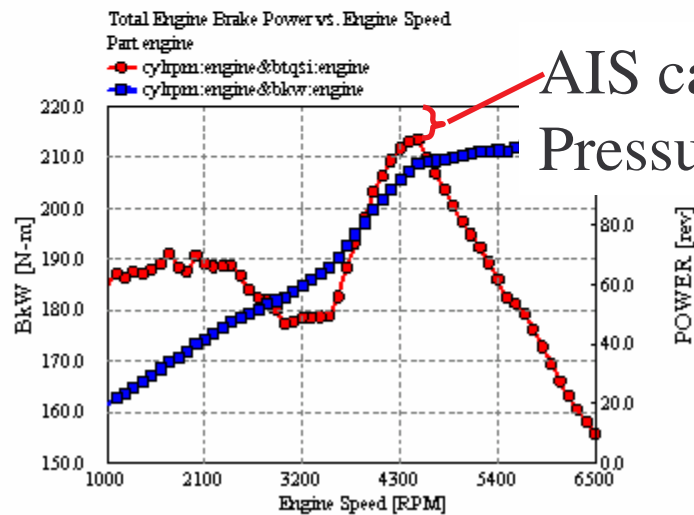
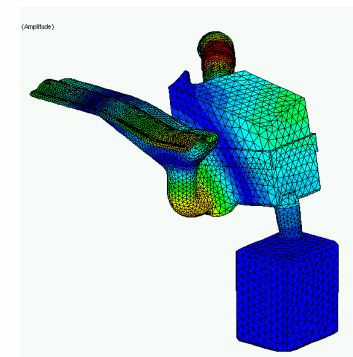
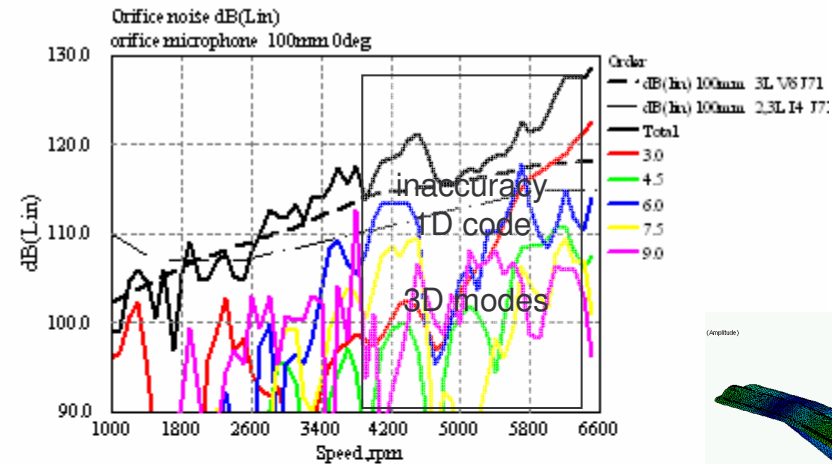
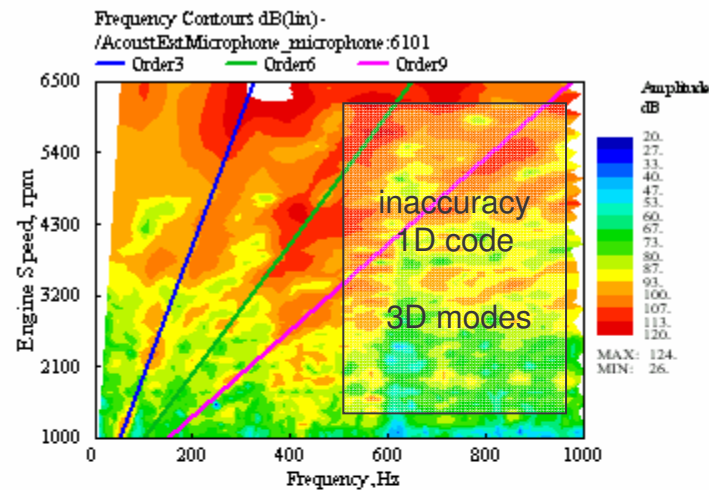


CD338_base01.gb

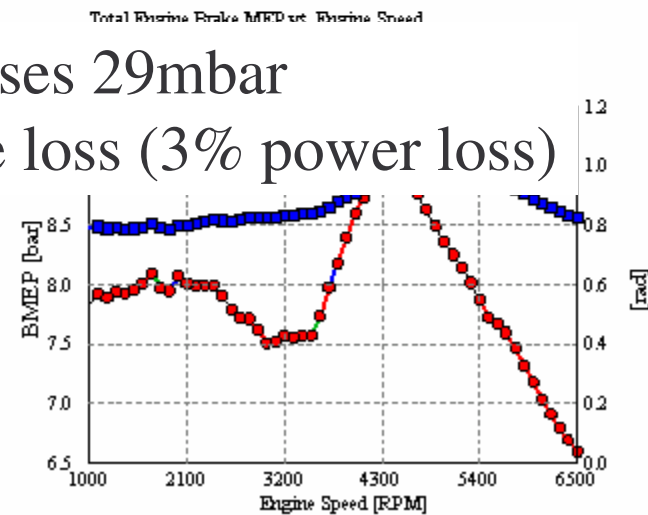
GT-POWER 5.1

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AIS causes 29mbar
Pressure loss (3% power loss)



GT-results CD338_base01_noSBR.gb

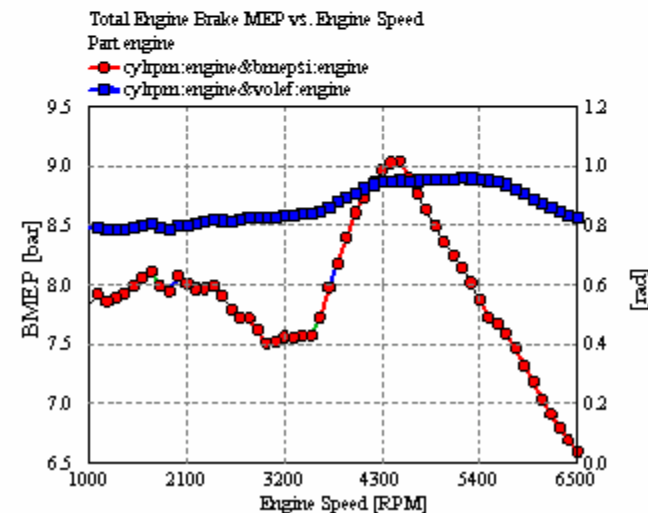
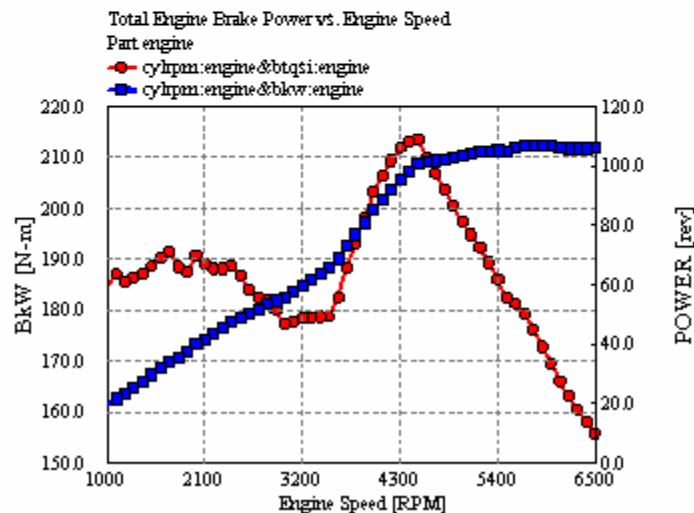
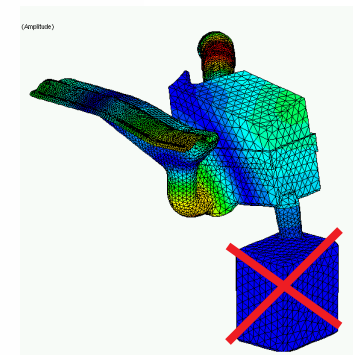
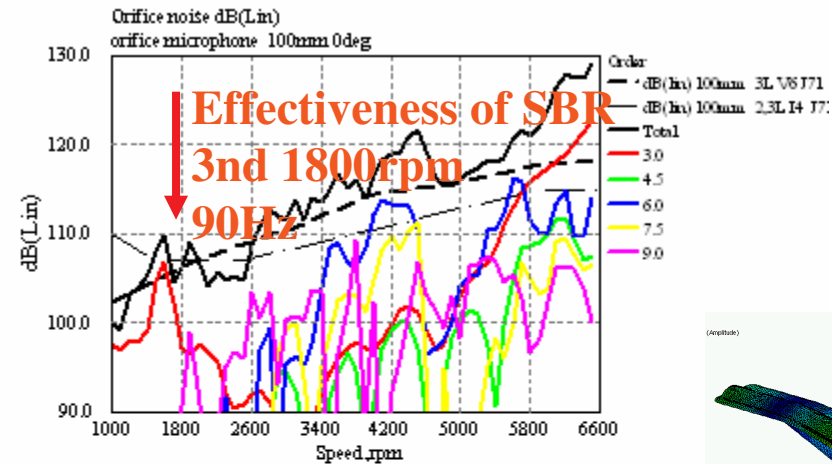
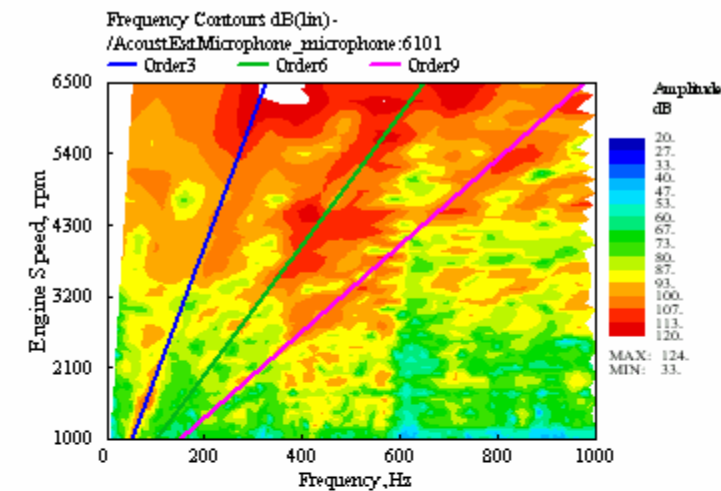


CD338_base01_noSBR.gb

GT-POWER 5.1

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GT-results CD338_base02.gb

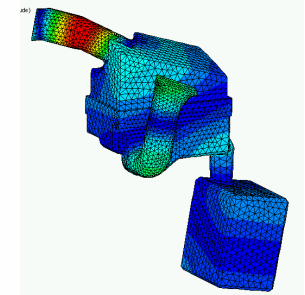
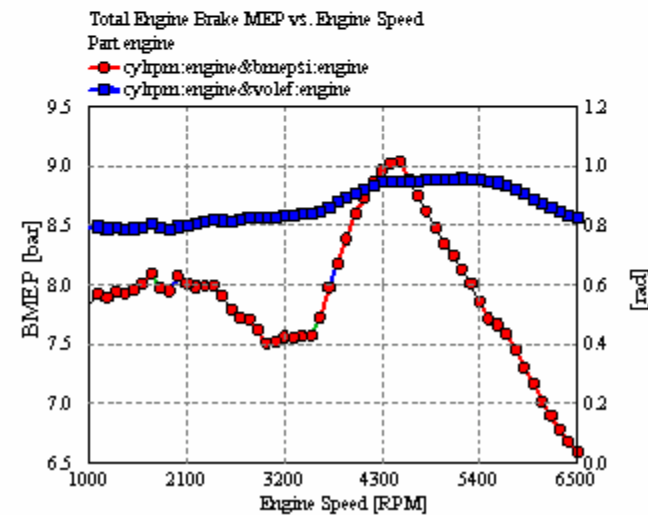
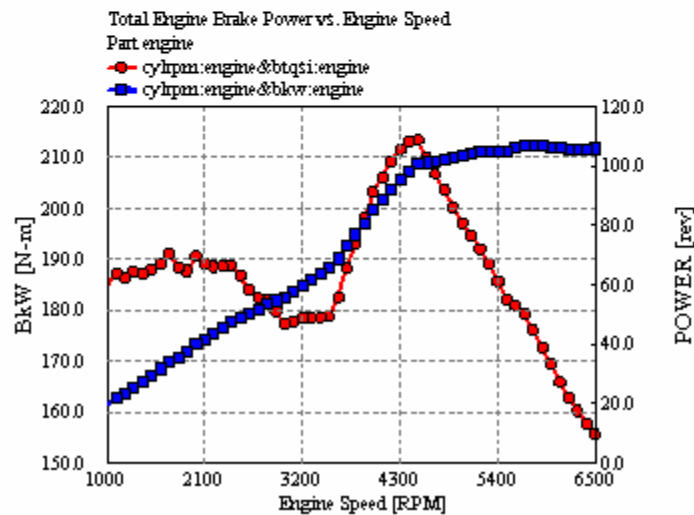
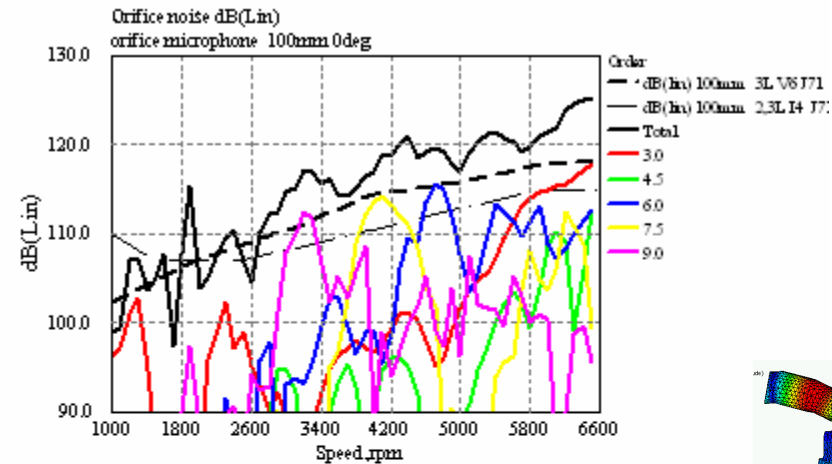
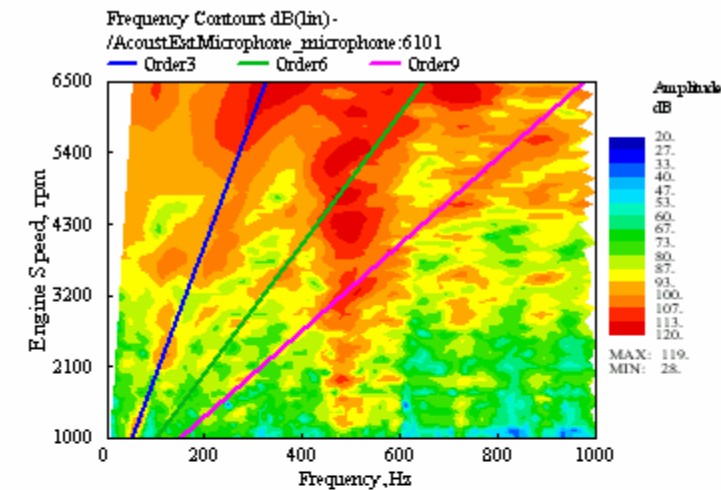


CD338_base02.gb

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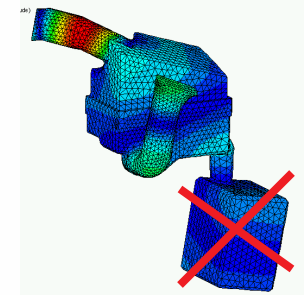
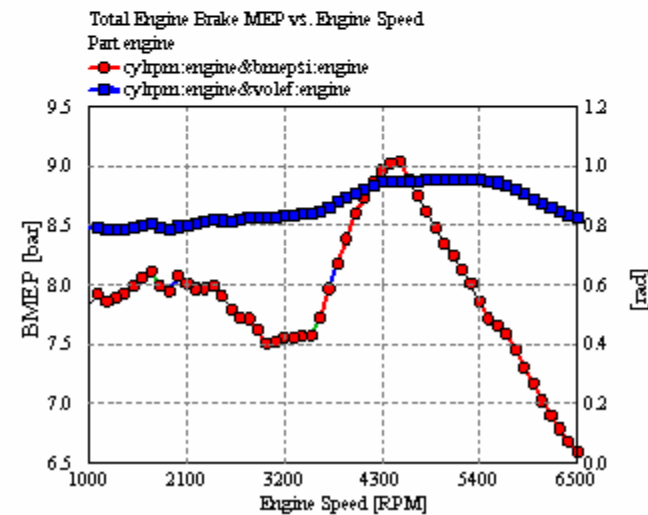
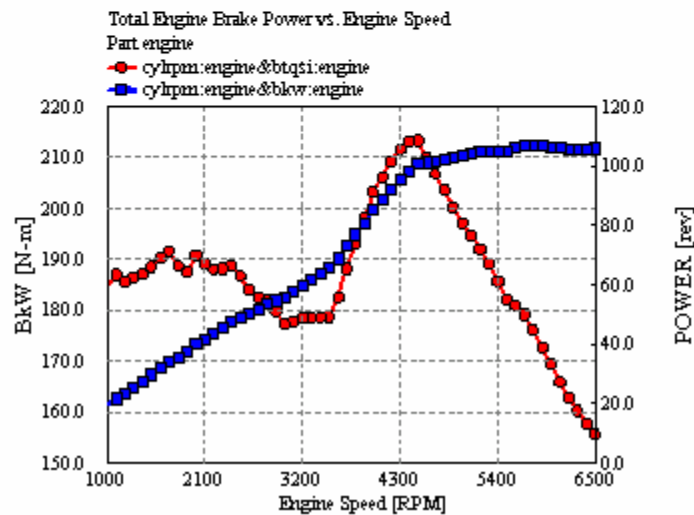
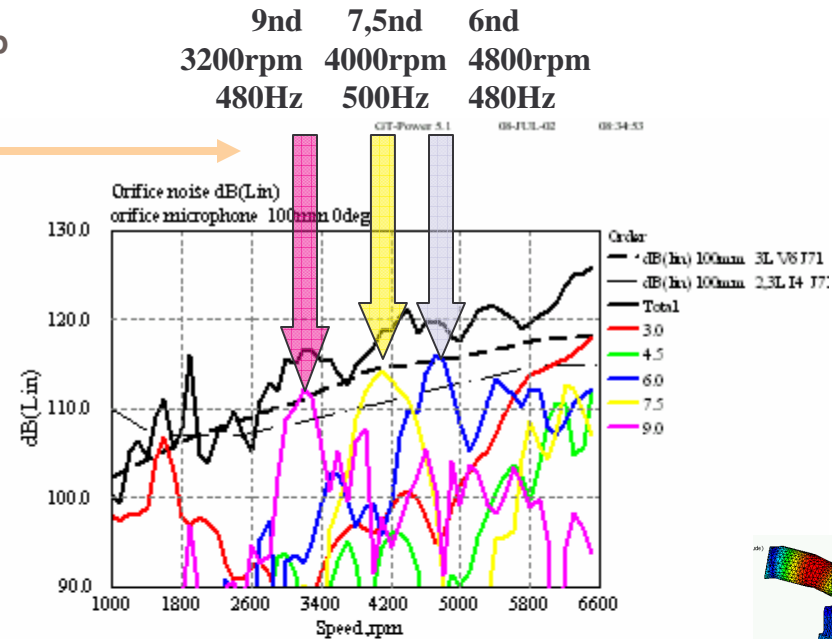
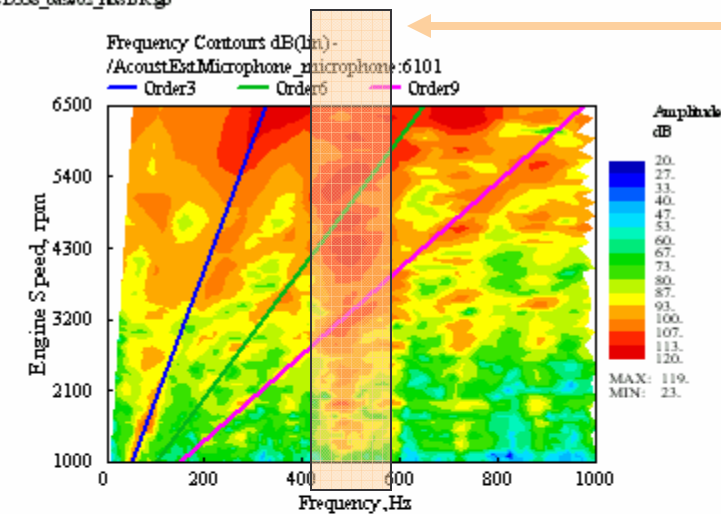
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GT-results CD338_base02_noSBR.gb



CD338_base02_noSBR.gb



GT-results CD338_base02_noSBR_perf.gb

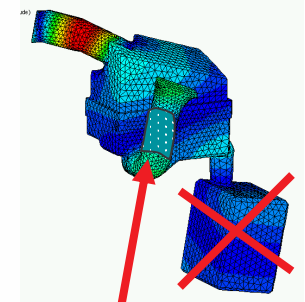
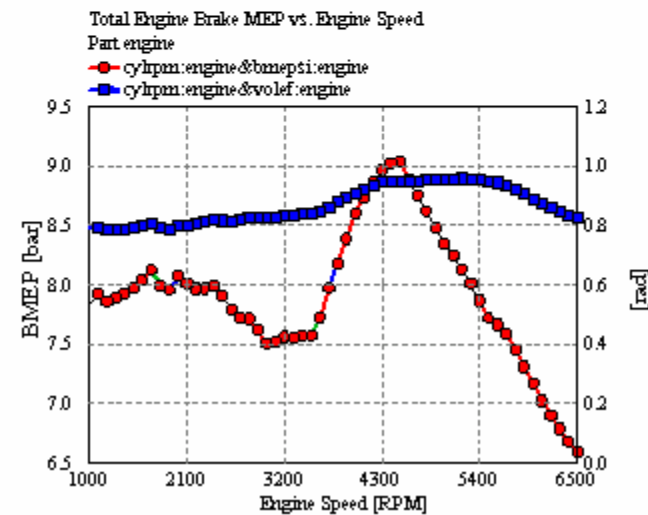
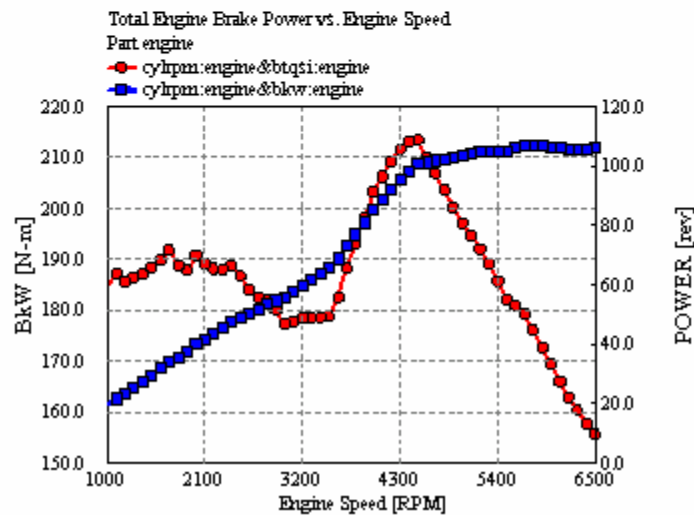
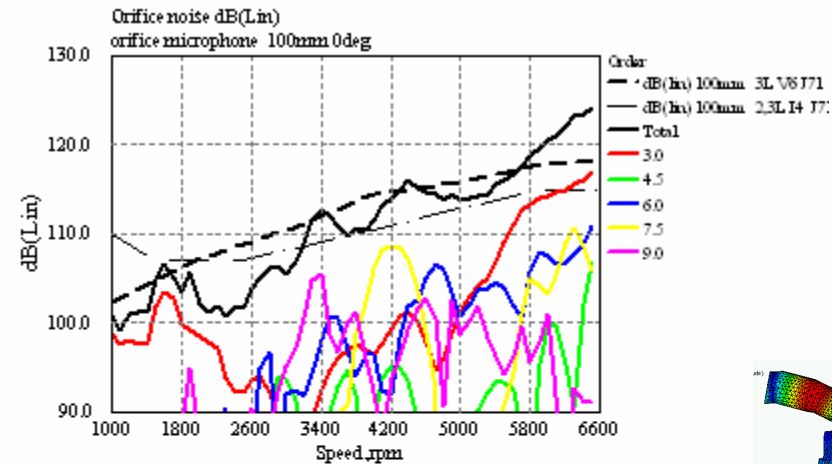
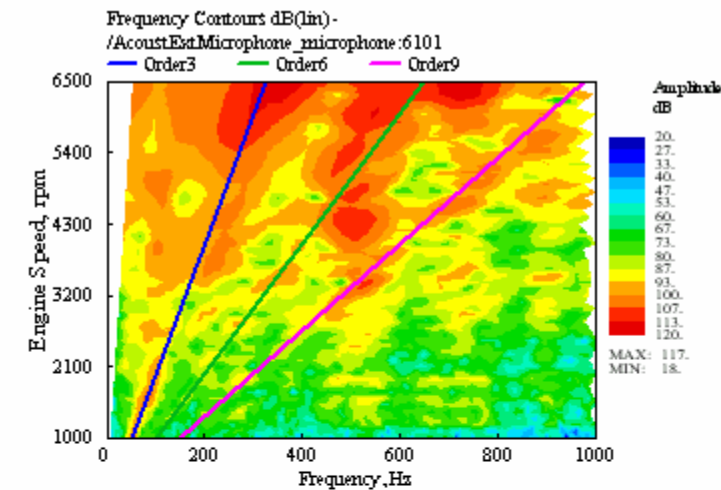


CD338_base02_noSBR_perf.gb

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Intake duct
Perforation
72 x Ø2mm

GT-results CD338_base02_500HzSBR_perf.gb

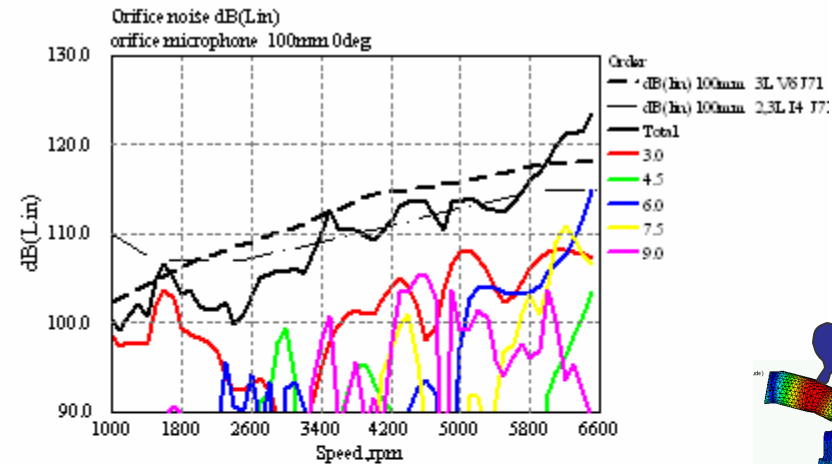
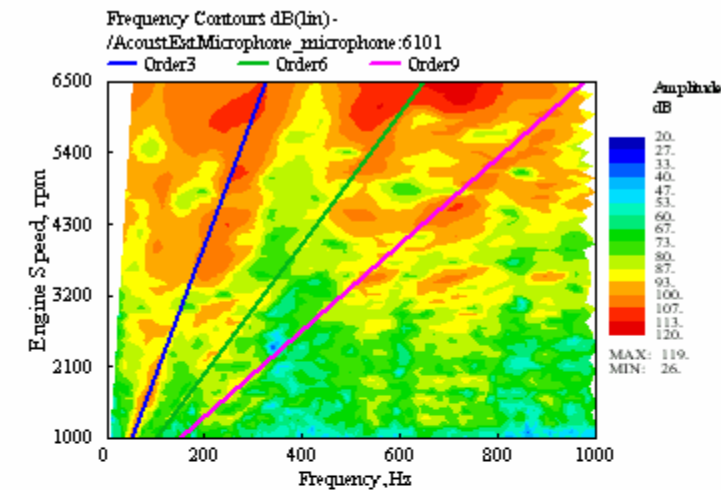


CD338_base02_500HzSBR_perf.gb

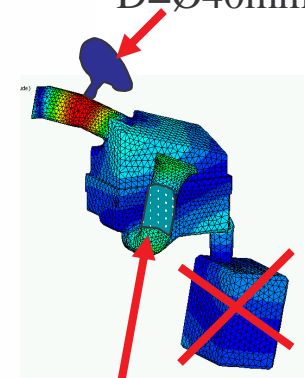
GT-POWER 5.1

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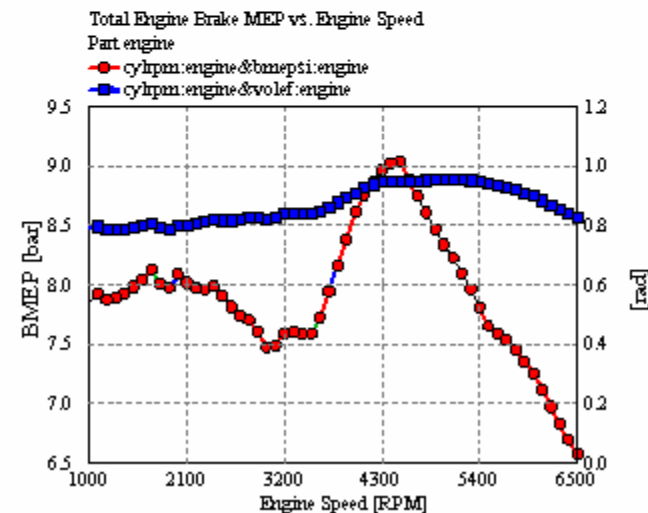
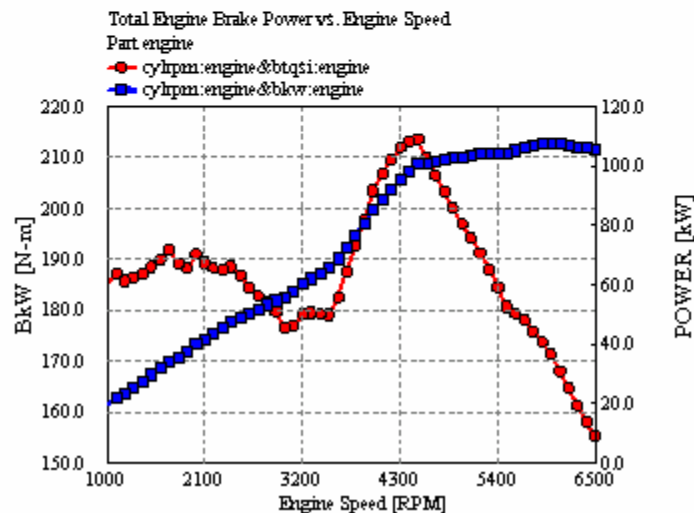
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500Hz SBR
V=500ml
L=20mm
D=Ø40mm



Intake duct
Perforation
72 x Ø2mm



GT-results CD338_base02_500HzSBR.gb

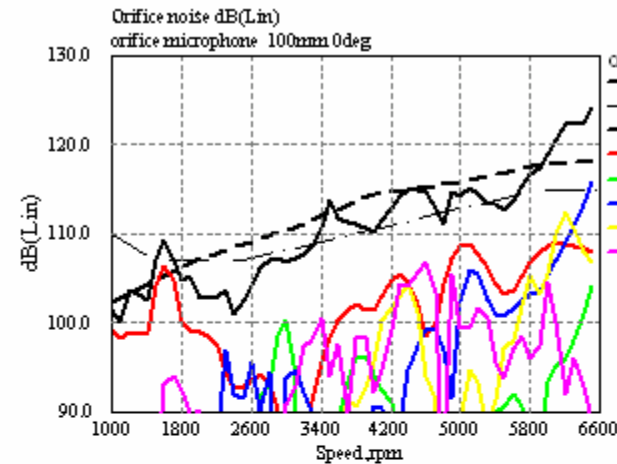
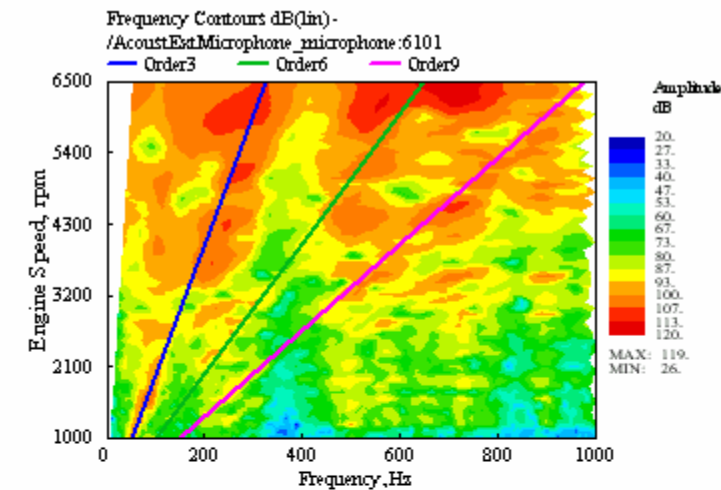


CD338_base02_500HzSBR.gb

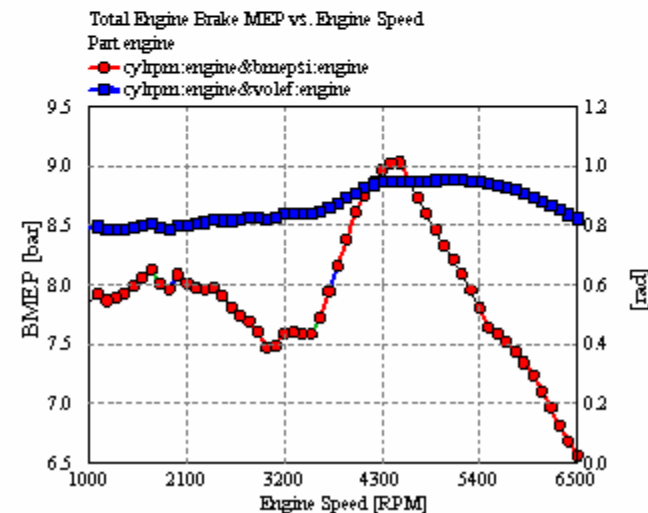
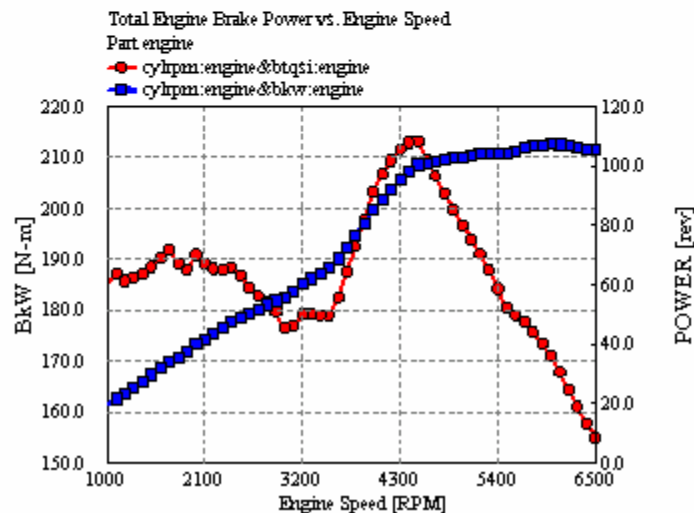
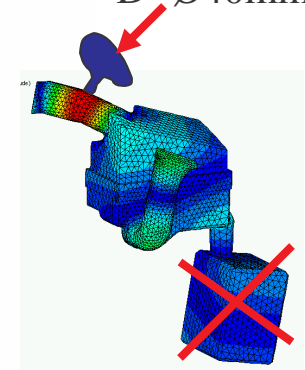
GT-POWER 5.1

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500Hz SBR
V=500ml
L=20mm
D=Ø40mm

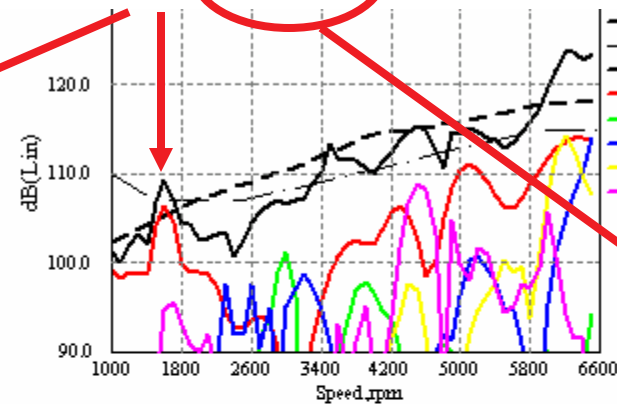
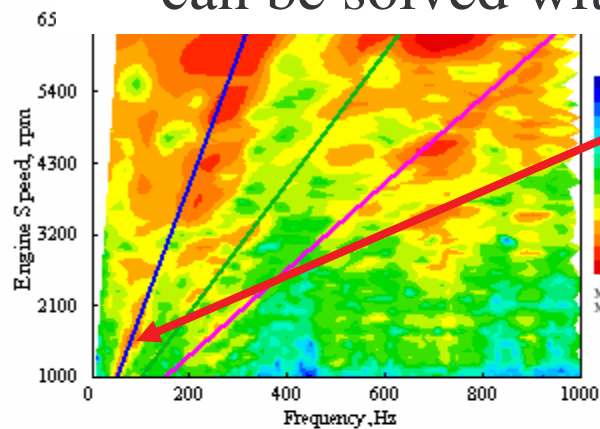


GT-results CD338_base02_500HzSBR_L4.gb

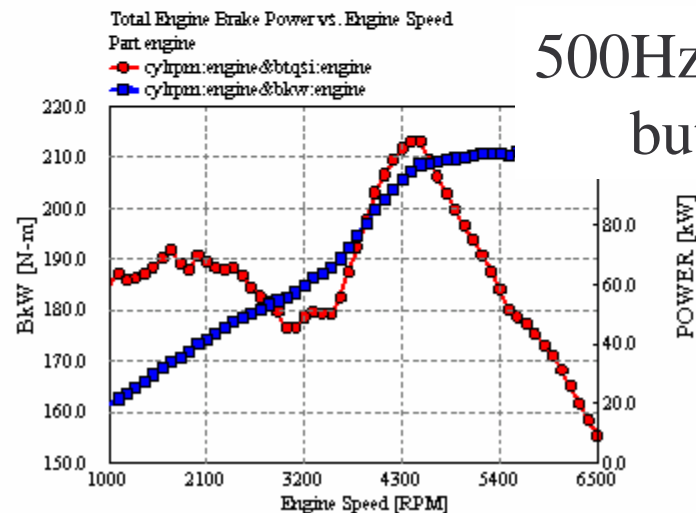
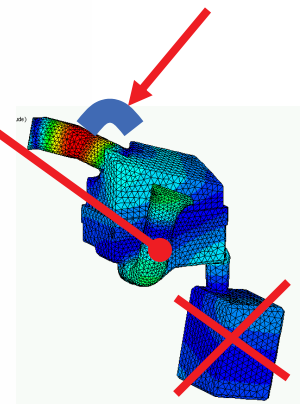


CD338_base

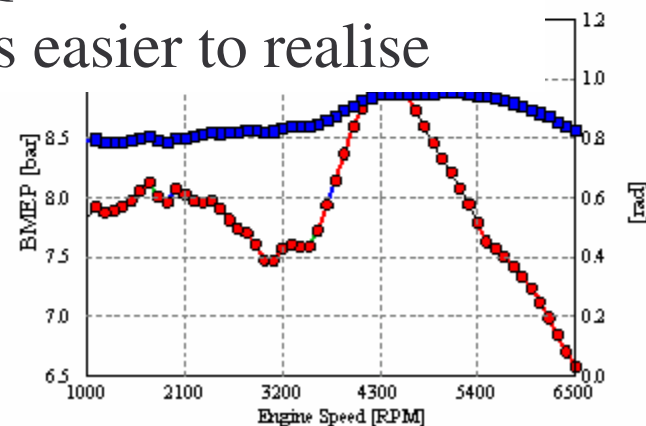
80Hz boost problem at 1600rpm
can be solved with additional SBR in dirty pipe



500Hz $\lambda/4$
L=172mm
D=Ø70mm



500Hz QWT similar to SBR
but is easier to realise



GT-results CD338_base02_500HzSBR_L4_80Hz_SBR.gb

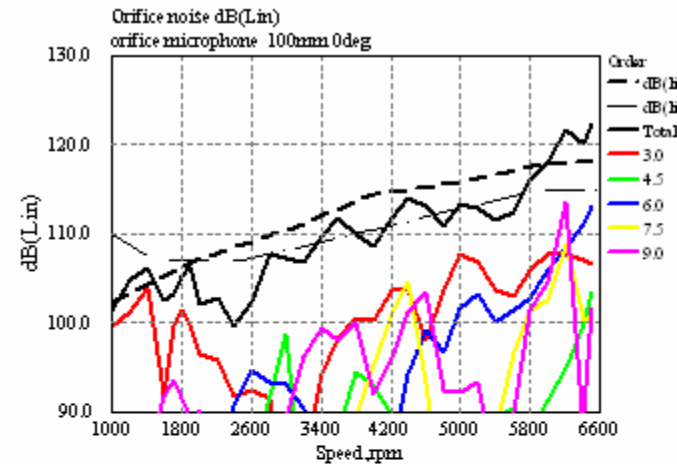
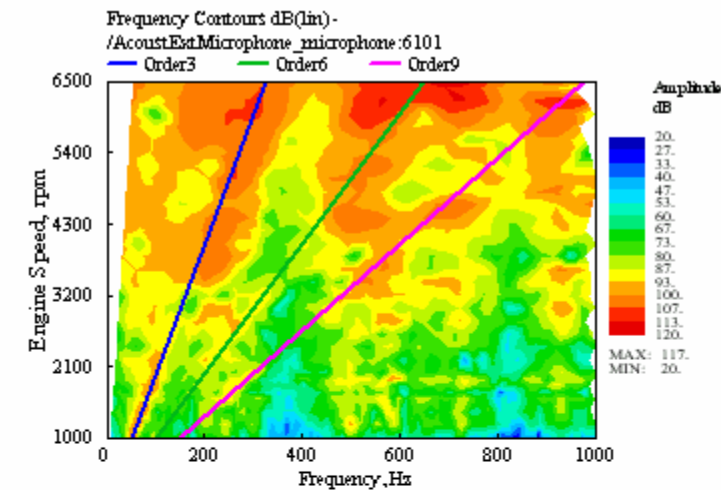


CD338_base02_500Hz_L4_80Hz_SBR.gb

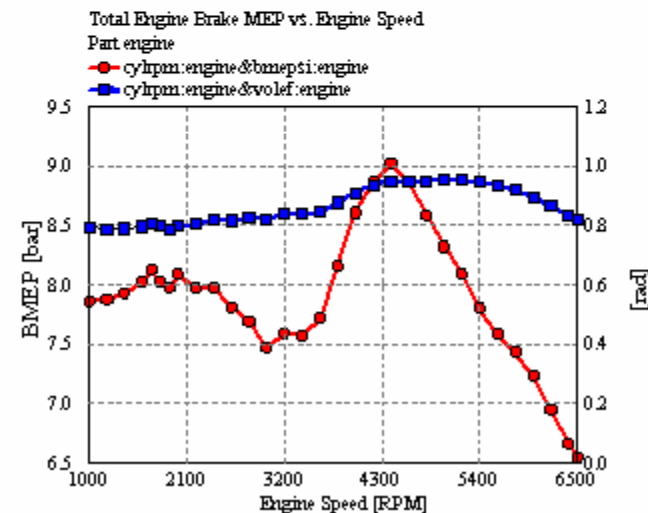
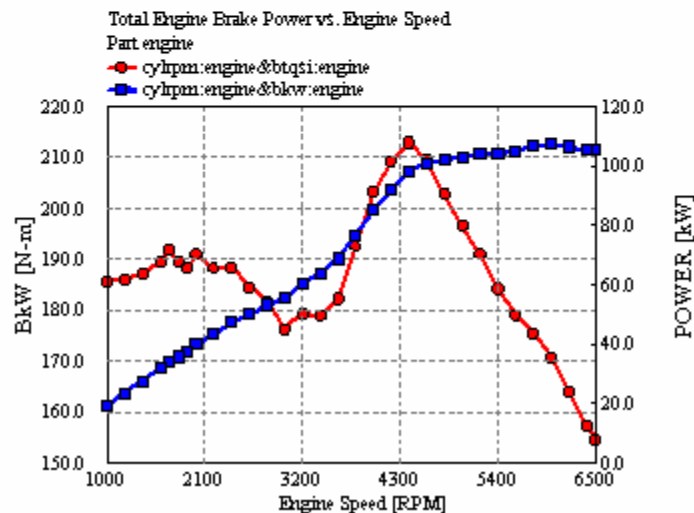
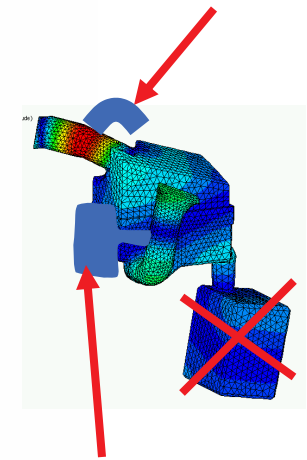
GT-POWER 5.1

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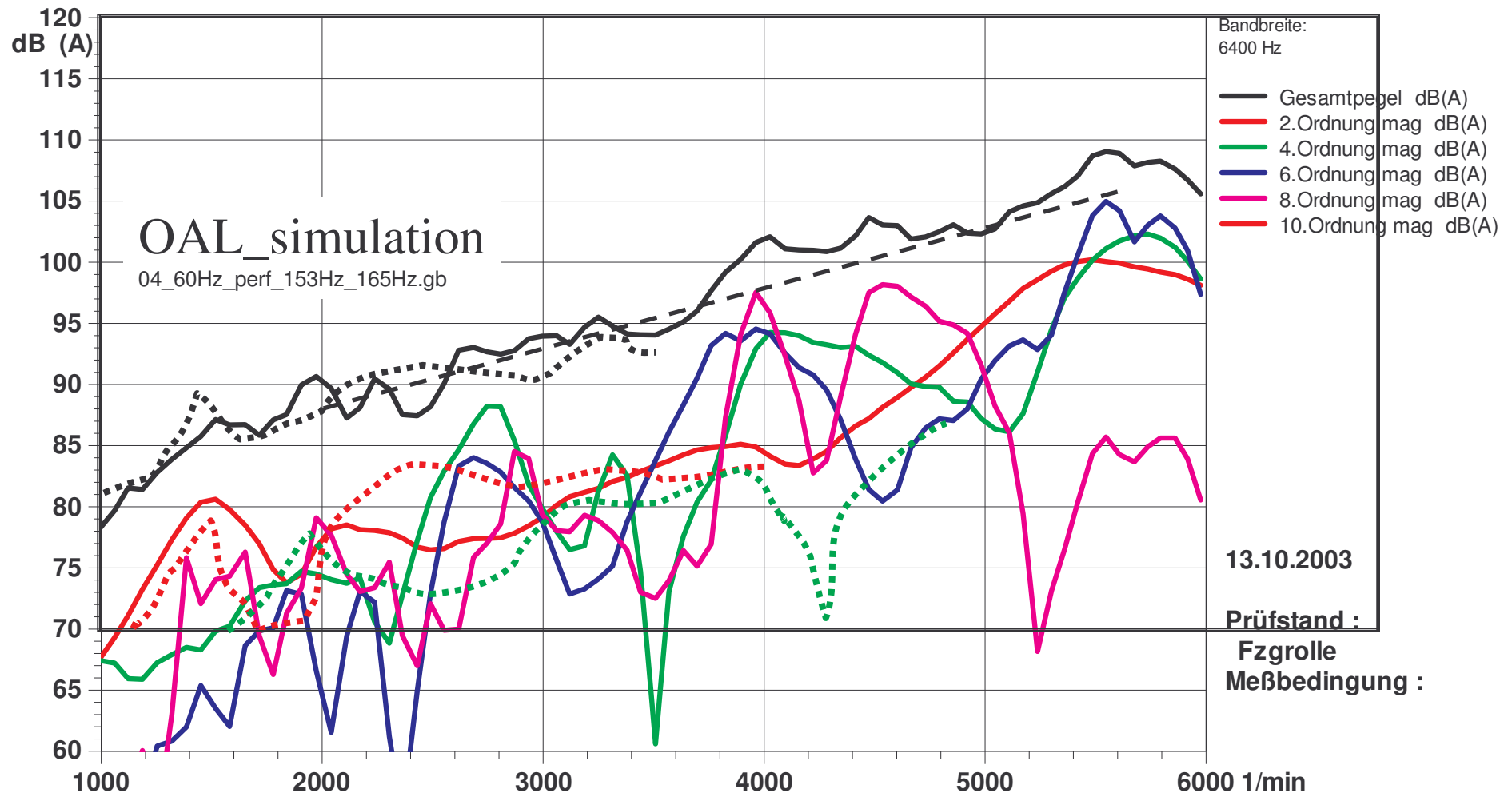
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500Hz $\lambda/4$
L=172mm
D=Ø70mm



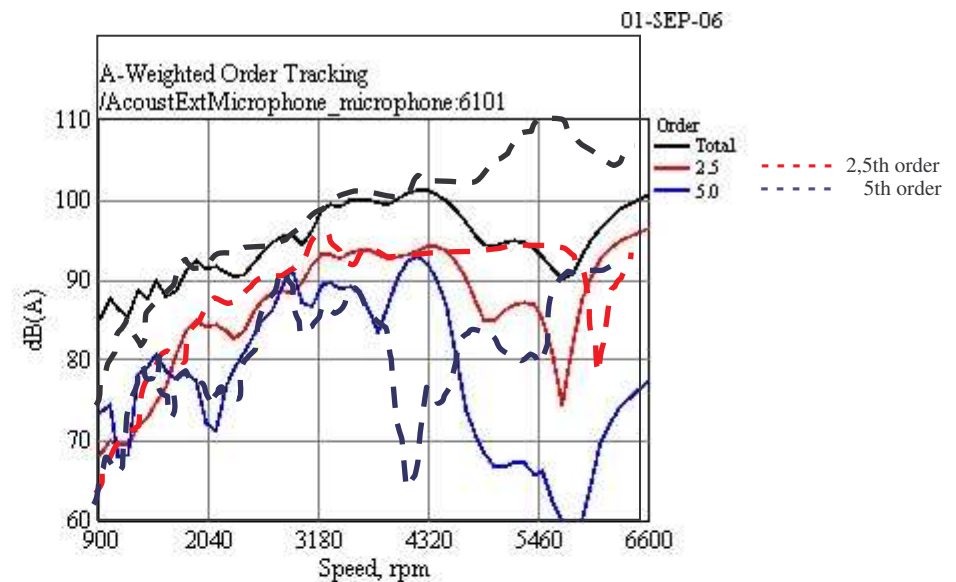
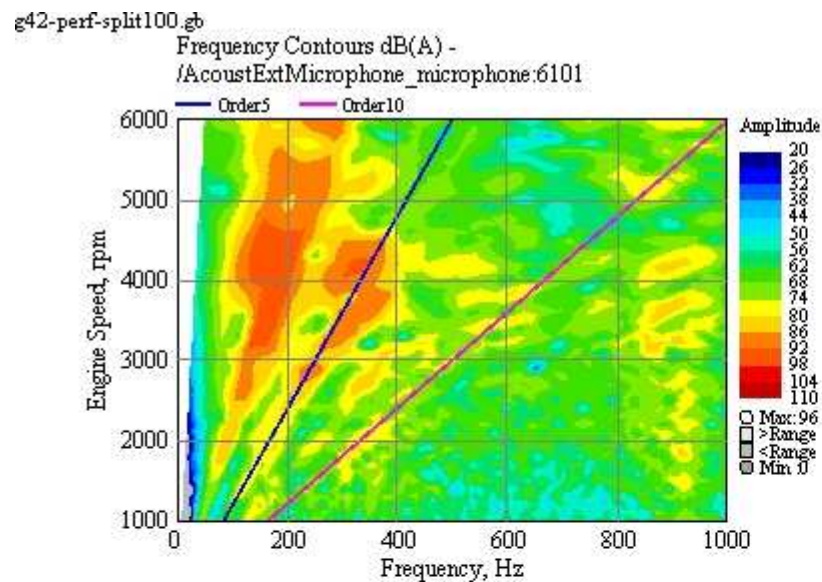
80Hz SBR
V=3,0L
L=167mm
D=Ø40mm



Post processing and OAL analysis

- dB(lin) orifice results for 2,5L 5cyl. engine
- campbell and order analysis

OAL measurement



Conclusion



- GT Power is sufficient orifice noise prediction and quick design studies
- GT Power is capable to perform attenuation analysis of AIS
 - with Transmission Loss & Transfer Function analysis
- Limitations to be taken in consideration
 - 1D simplification → no turbulences , acoustic wave reflections
 - no panel mode feed back effect of structure dynamics
- increasing computing power will led to acceptable simulation time for
 - computing in the 3D domain at least for the air intake system
 - coupled simulation together with structure dynamic analysis and feed back to the gas-medium

- Thank You for your attention !