Reduction of Boiler Hum

COMSOL CONFERENCE 2014 CAMBRIDGE

Bouw
Ruimte
Milieu

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Overview presentation

- Problem
- Low Frequency Noise
- Acoustic analysis
- Flow analysis
- Results of measures

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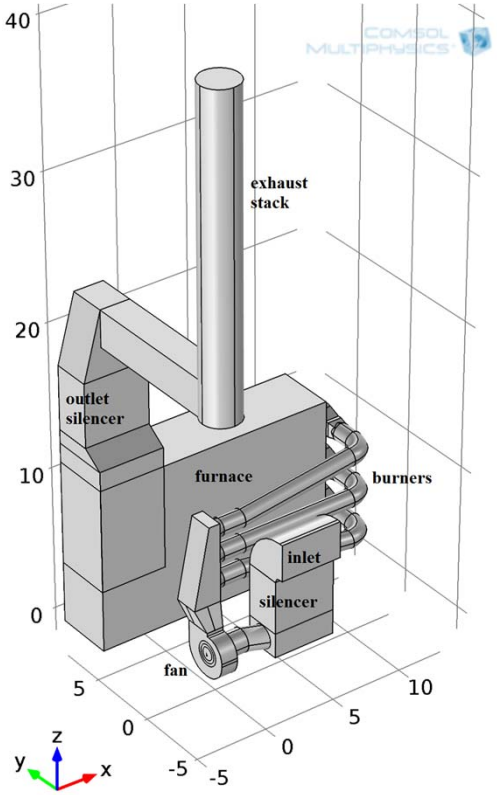

Low frequency hum of boiler

- 220 ton/hr steam; 70 – 78 bar
- Complaints of nearby residents of noise around 30 Hz
- Strong movement of boiler parts
- Between 66 – 80 % boiler load

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Possible causes of boiler hum

- flow around pipes in heat exchangers (excluded)
- fan
  - here not blade passing frequency
- fan inlet valves
- burner control valves (excluded)
- burners (excluded)
- flow in ducts

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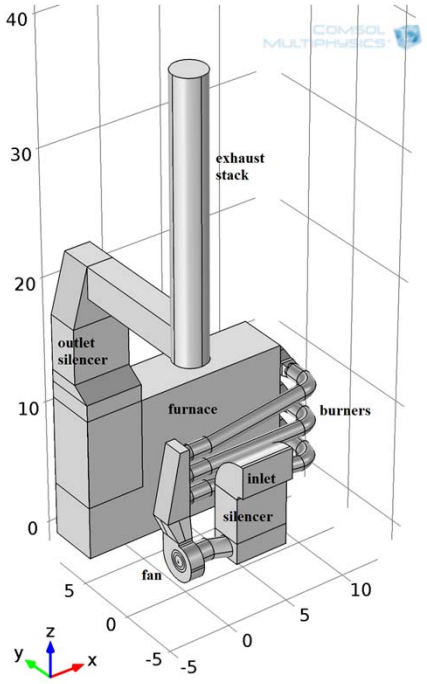
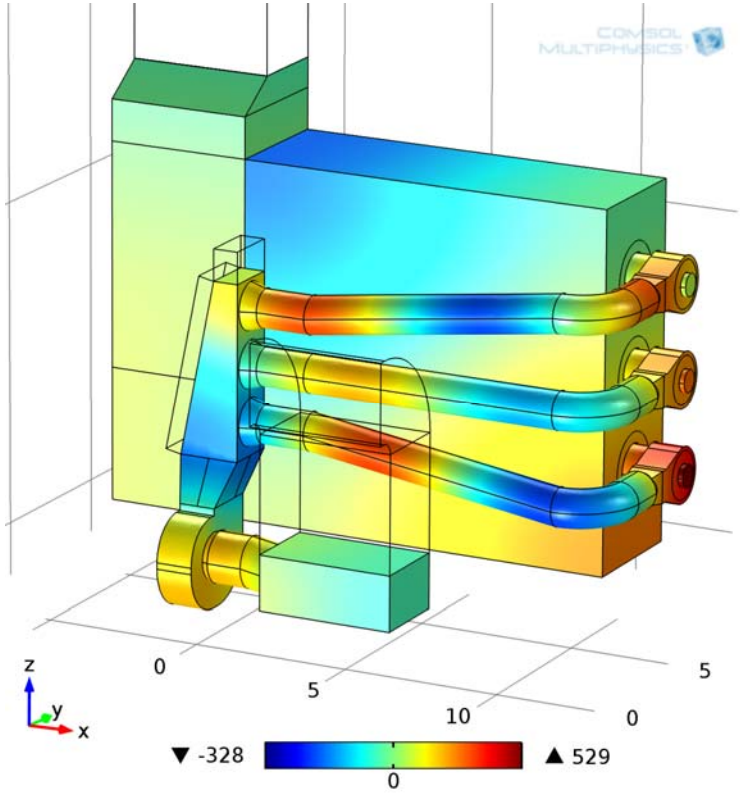
Acoustic analysis

- Expected source: fan
- Model of complete boiler
- Temperatures taken into account
  - ambient: 15 ºC
  - furnace: 1000 ºC
  - stack: 140 ºC
- inlet and end conditions:
  - impedance acc. Levine&Schwinger
- Silencer:
  - reduction / m calculated in separate model
- Lp in furnace at given Q-ac.(fan)



Mode at 30 Hz



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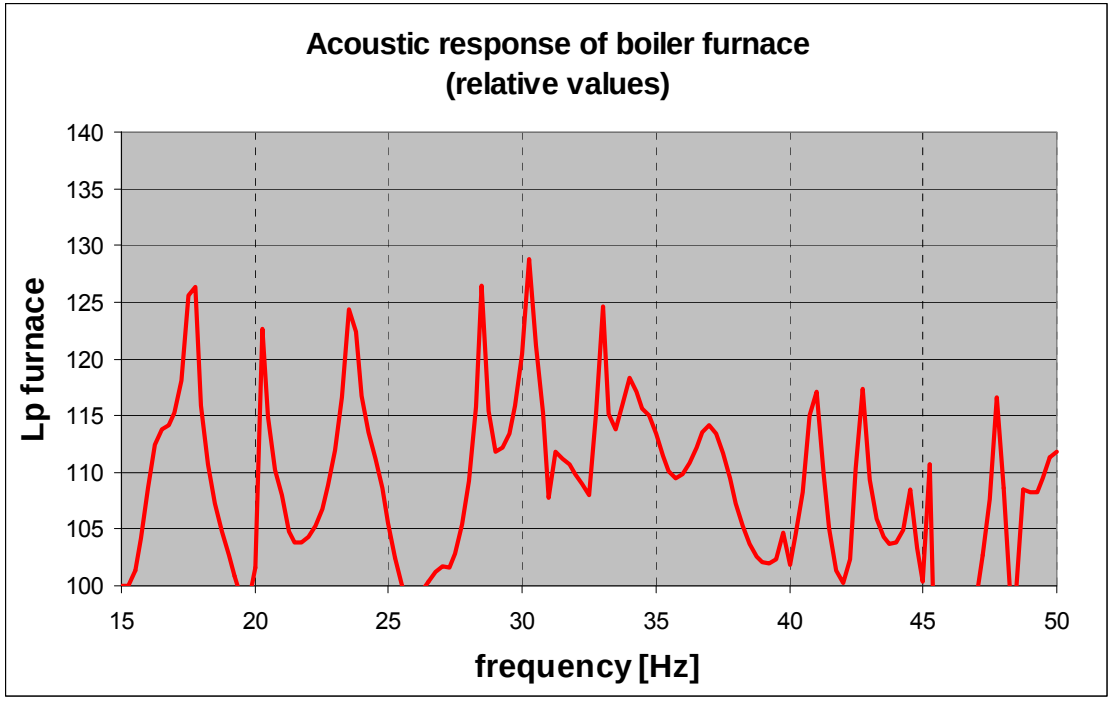
Acoustic response of boiler furnace
(relative values)
Lp furnace
140
135
130
125
120
115
110
105
100
15
20
25
30
35
40
45
50
frequency [Hz]

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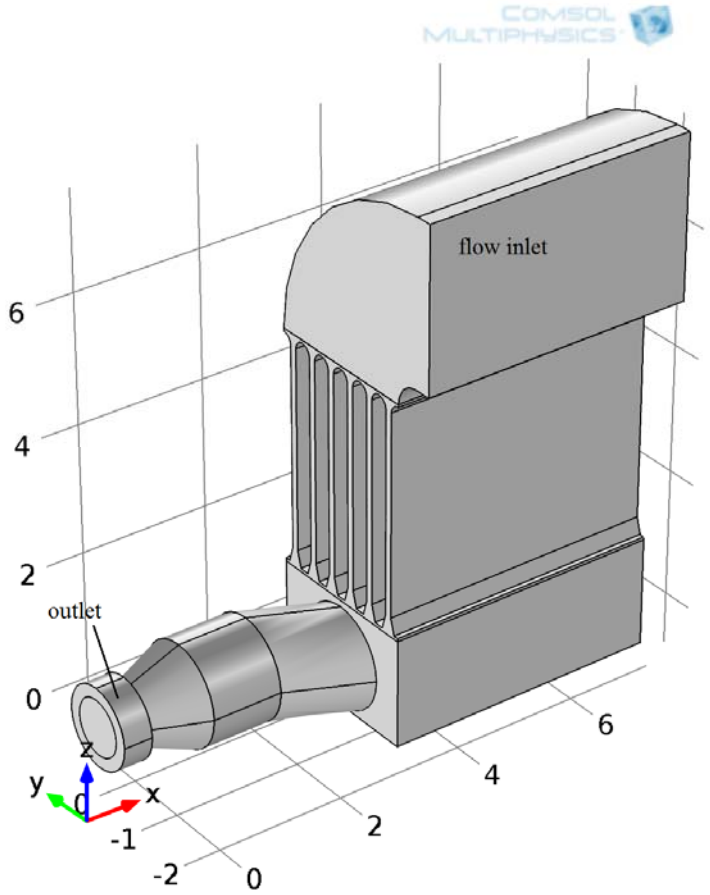
Results acoustic study

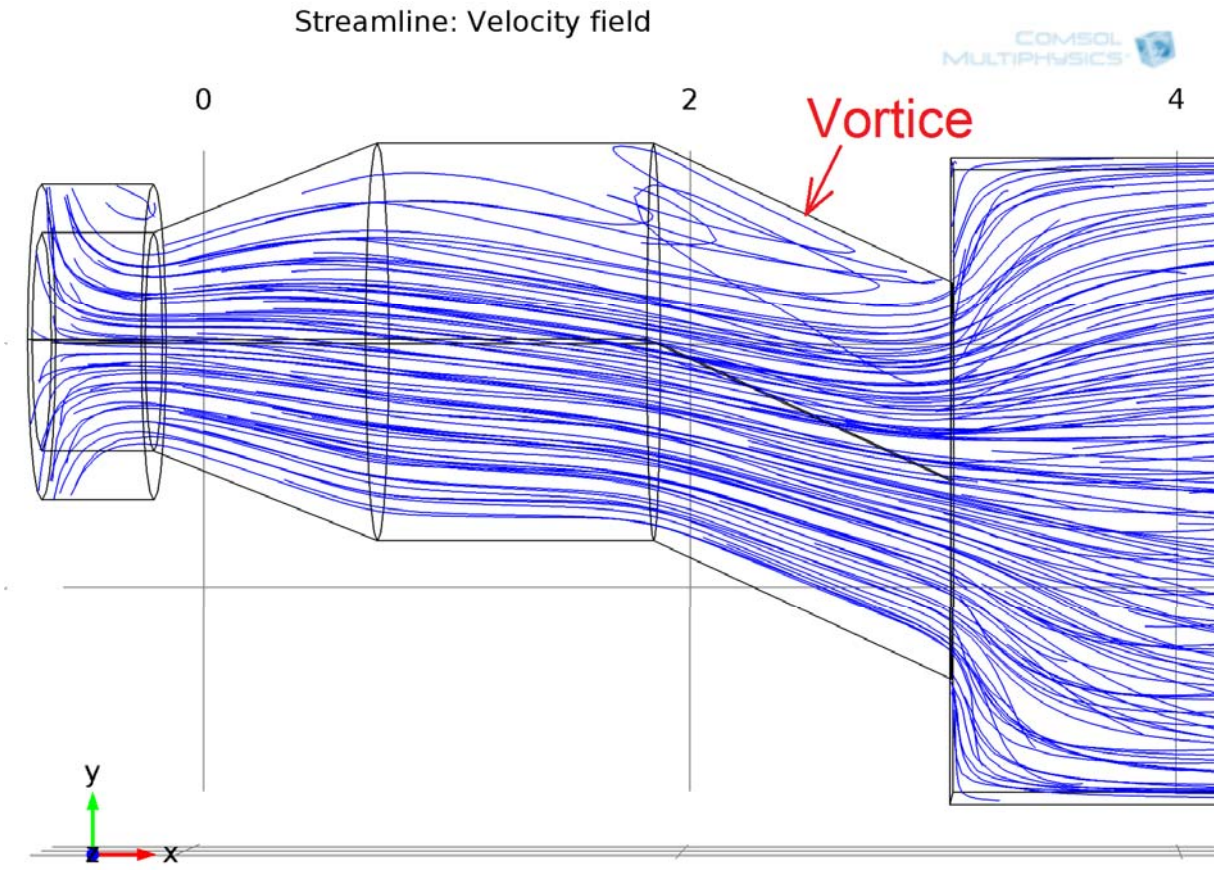
- Sensitive behaviour boiler around 30 Hz shown
- No answers about cause of noise
- Further study for sources necessary

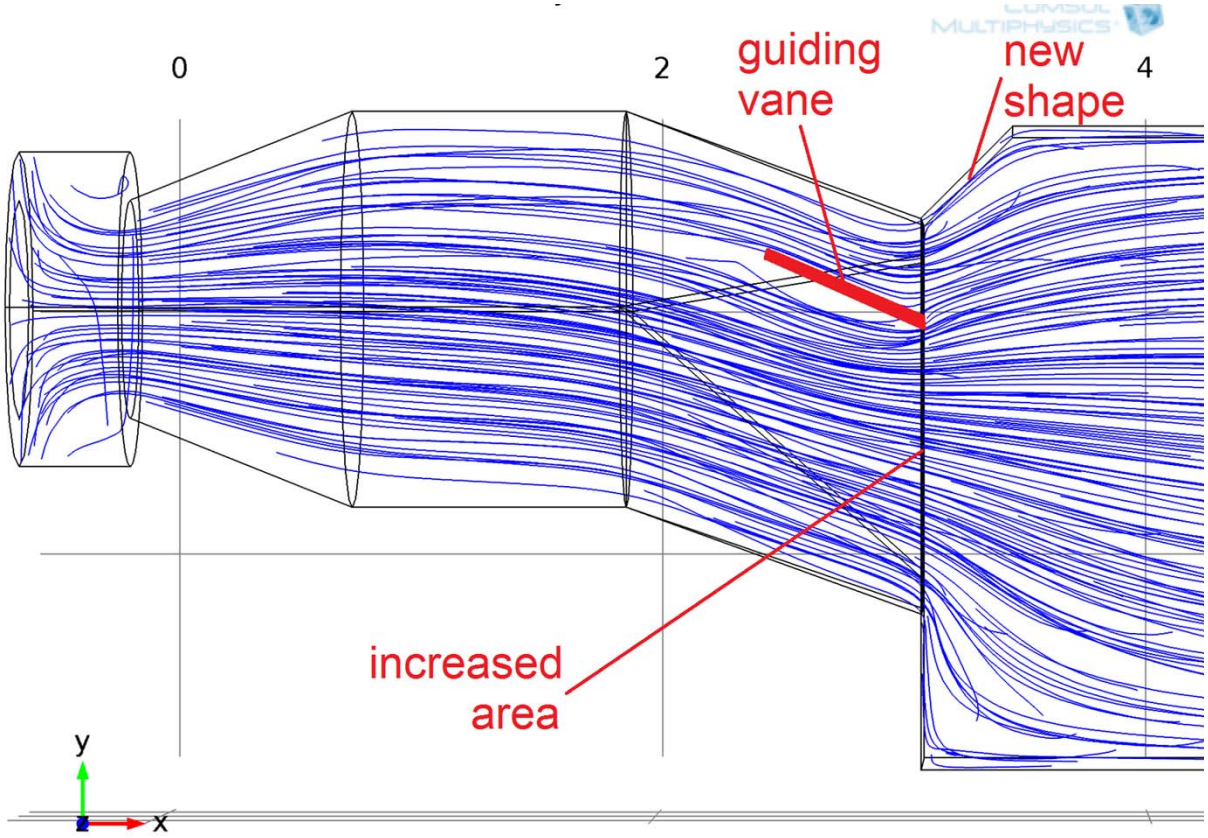
Flow analysis inlet air to fan

- air flow:
- 44 m^3/s at 100%

- RANS
- k-ε model

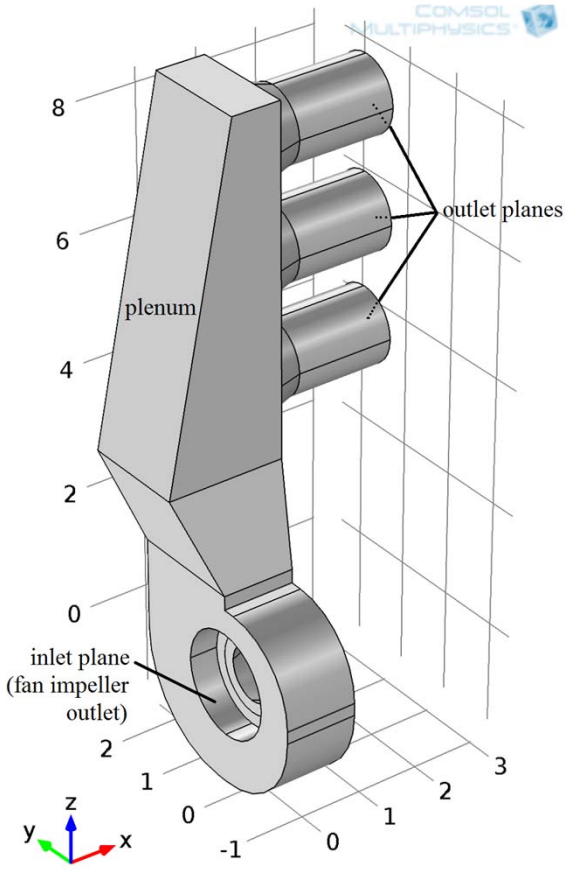



Streamline: Velocity field
COMSOL MULTIPHYSICS
0
2
4
Vortice
y
x


0
2
4
guiding
vane
new
shape
increased
area
y
x

Flow analysis fan outlet area

- air flow:
- 44 m^3/s at 100%



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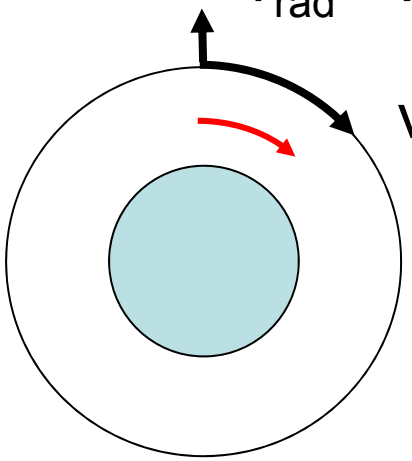
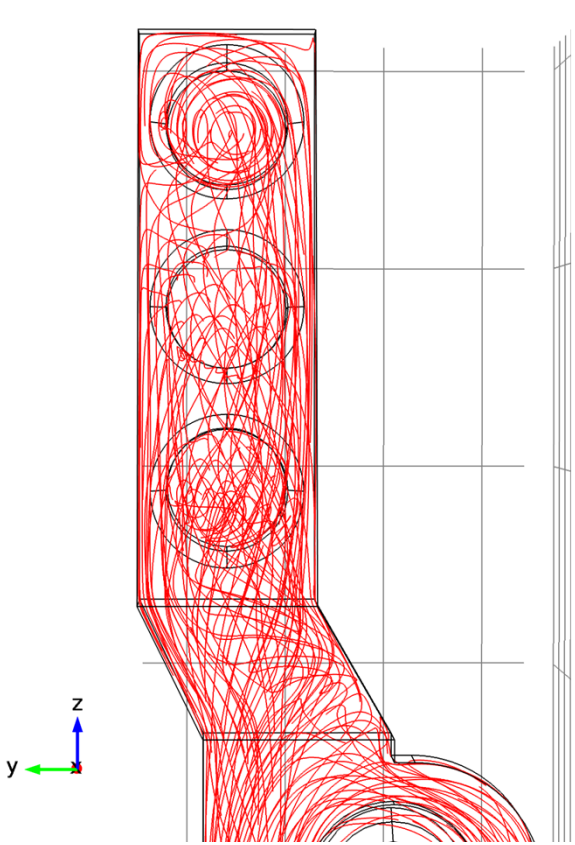
Starting conditon velocity (outlet radial fan)

$$v_{rad} = W_{tot}/(2 \cdot \pi \cdot r_{imp} \cdot w_{imp})$$

$$v_{tan} = \omega \cdot r_{imp}$$



Streamline: Velocity field



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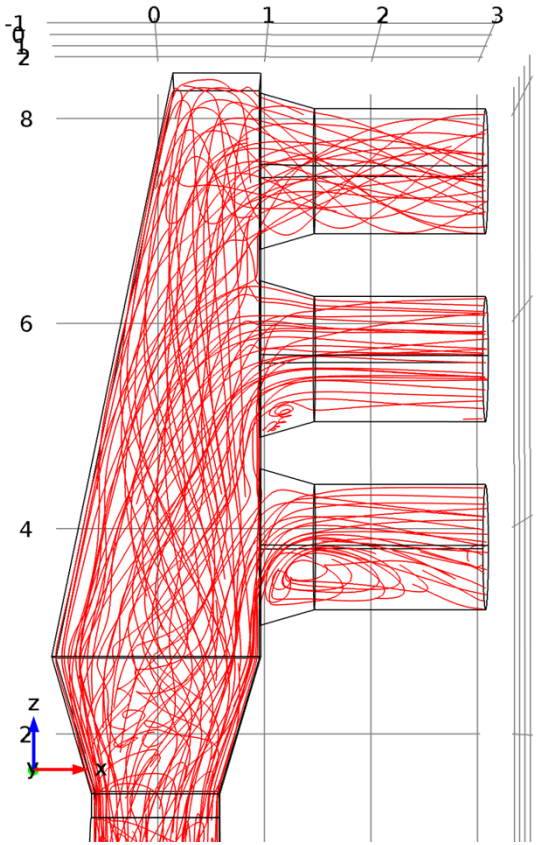
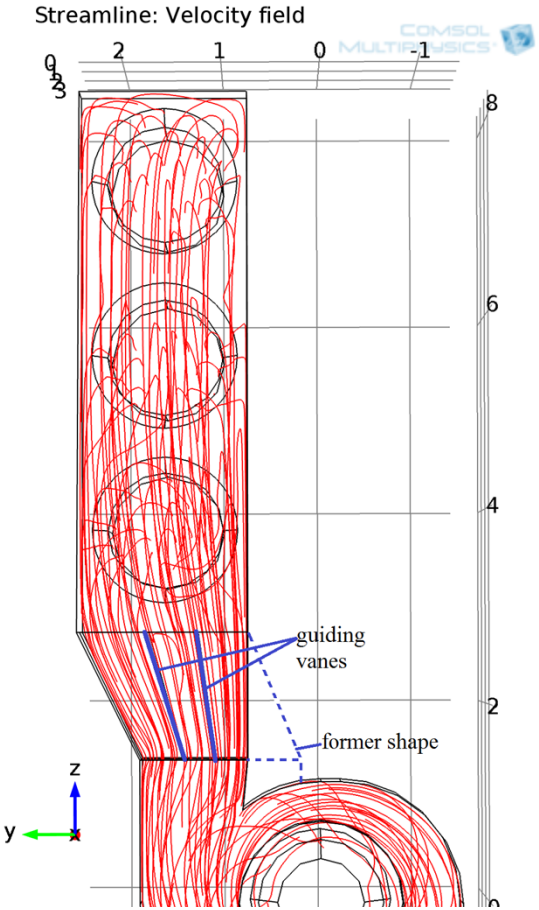
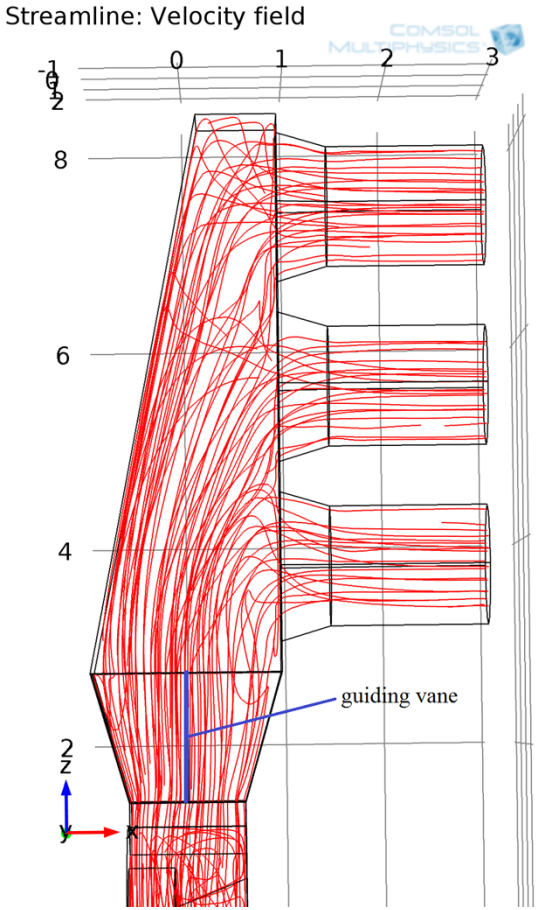



Streamline: Velocity field
guiding vanes
former shape
z
y
x


Streamline: Velocity field
guiding vane
z
y
x

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Results flow study

- Original inlet design causes vortice
- Redesign was made

- Fan outlet duct also causes vortices and unstable flow
- Redesign was made

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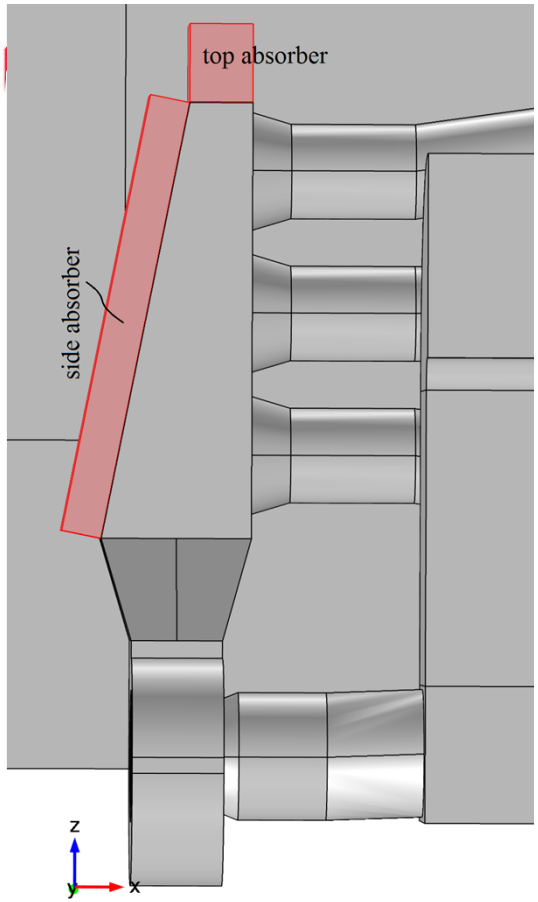
Additional acoustic measures

- absorption section on top:
- 1 m thick

- absorption at wall
- 0.5 m thick



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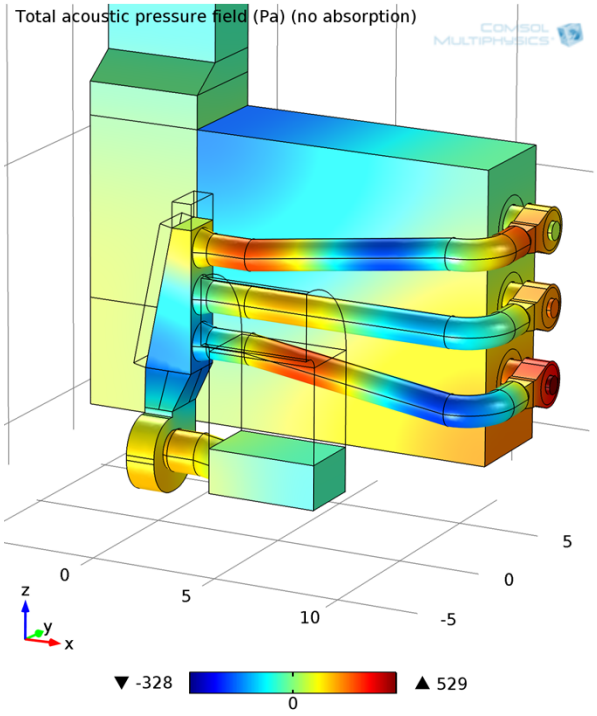
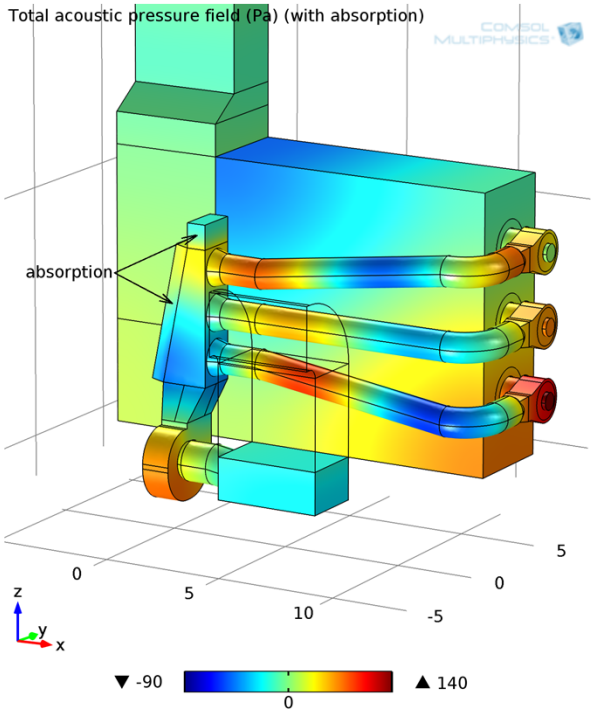
Effect acoustic measures





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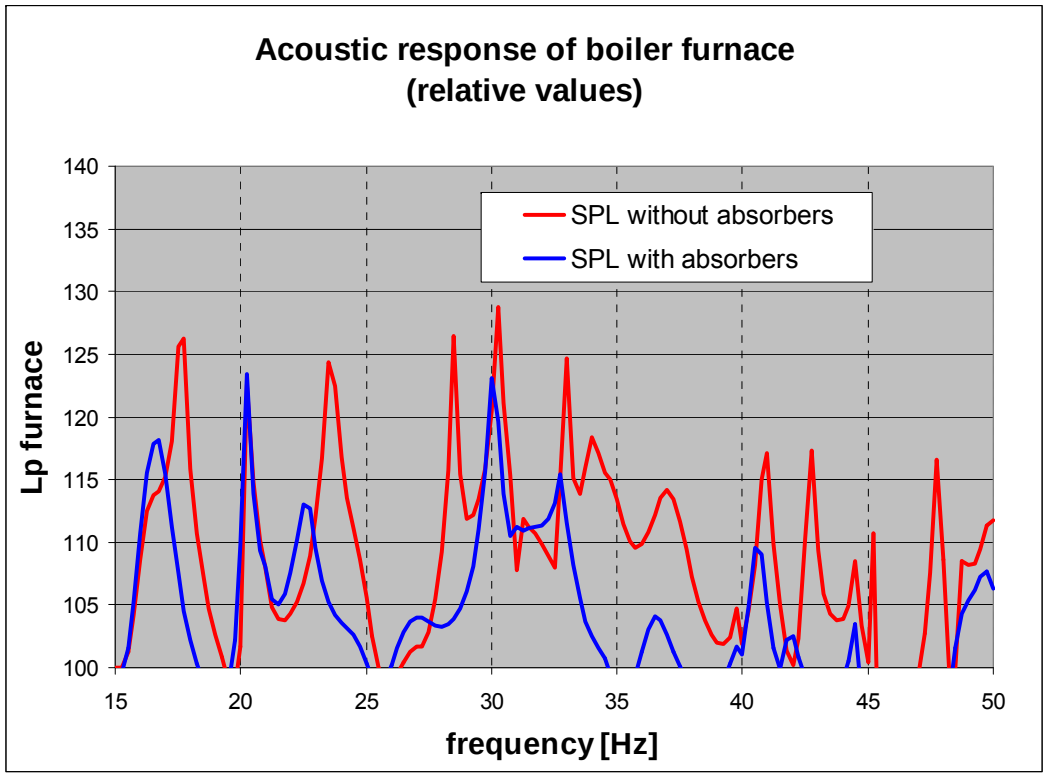
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frequency [Hz]
SPL without absorbers
SPL with absorbers

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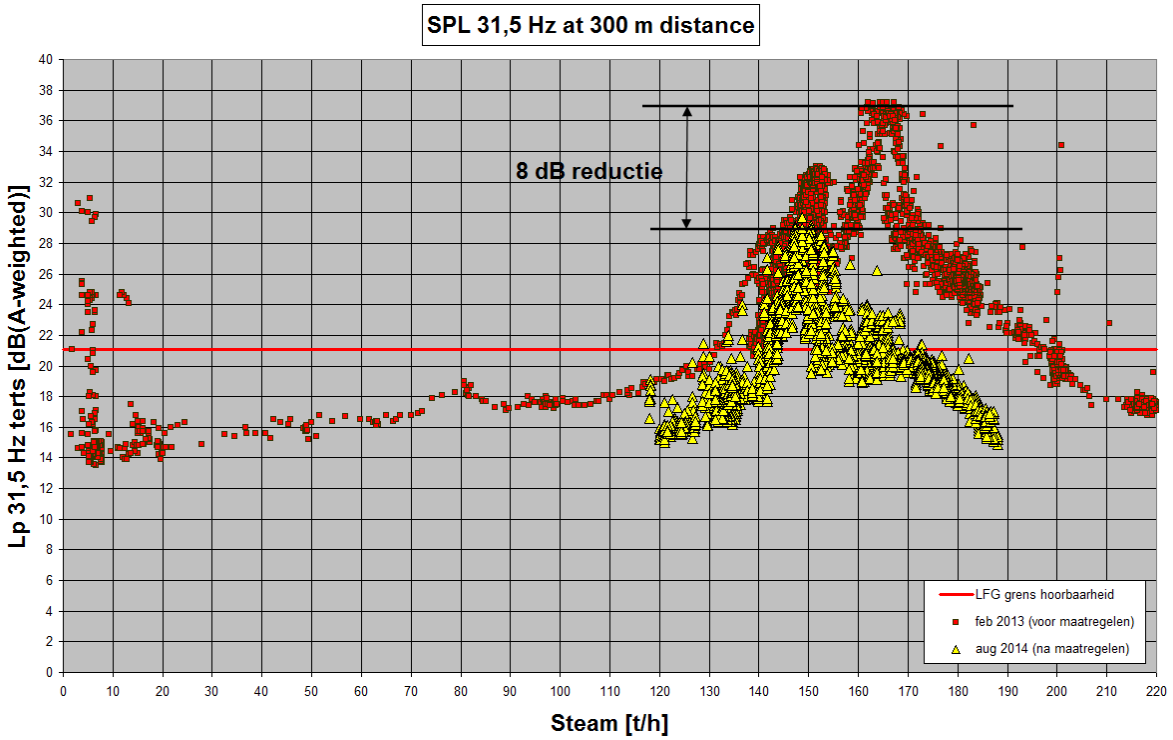
Summary absorptive measure

- 5 dB at 30 Hz
- (reduction for one pass from fan to furnace)
  - effect to environment < 5 dB
- More reduction at other modes

Total effect of measures



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Conclusions

- Comsol proved useful tool for:
  - acoustic study (understandig modes, etc.)
  - flow study
  - design of flow improvement
  - design of additional absorption
- Result: 8 dB improvement

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End

Thanks for your attention!