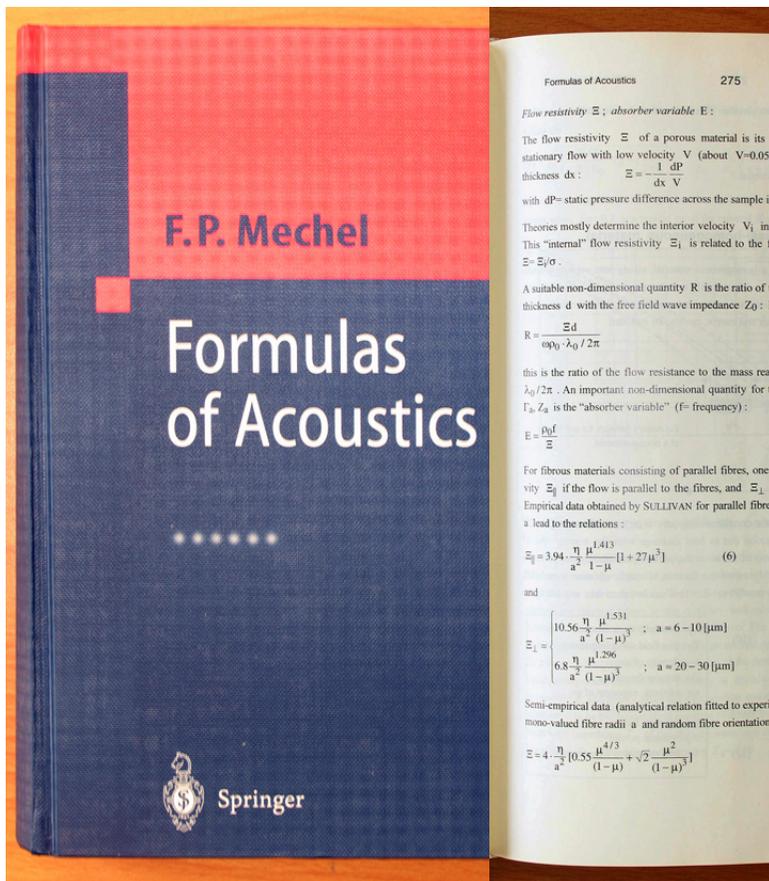


# Berechnung und Simulation akustischer Materialeigenschaften mit WinFlag

Mechel „Formulars of Acoustics“  
Physik; Mathematik pur

Morset Sound Development „WinFlag“  
Physik; Mathematik ► Software



Formulas of Acoustics 275

Flow resistivity  $\Xi$ ; absorber variable  $E$ :

The flow resistivity  $\Xi$  of a porous material is its flow resistance to a stationary flow with low velocity  $V$  (about  $V=0.05$  m/s) through a thickness  $dx$ :

$$\Xi = \frac{1}{dx} \frac{dP}{V}$$

with  $dP$  = static pressure difference across the sample in a thickness  $dx$ .

Theories mostly determine the interior velocity  $V_i$  in a porous material. This "internal" flow resistivity  $\Xi_i$  is related to the flow resistivity  $\Xi$  by:

$$\Xi = \Xi_i \sigma$$

A suitable non-dimensional quantity  $R$  is the ratio of the flow resistivity  $\Xi$  to the free field wave impedance  $Z_0$ :

$$R = \frac{\Xi d}{\rho_0 c_0 \lambda_0 / 2\pi}$$

this is the ratio of the flow resistance to the mass reactance  $\lambda_0 / 2\pi$ . An important non-dimensional quantity for the flow resistivity  $\Xi$  is the "absorber variable" ( $f$  = frequency):

$$E = \frac{D_0 f}{\Xi}$$

For fibrous materials consisting of parallel fibres, one defines  $\Xi_i$  if the flow is parallel to the fibres, and  $\Xi_{\perp}$  if the flow is perpendicular to the fibres. Empirical data obtained by SULLIVAN for parallel fibres lead to the relations:

$$\Xi_i = 3.94 \frac{\eta}{a^2} \frac{\mu^{1.413}}{1-\mu} [1 + 27\mu^3] \quad (6)$$

and

$$\Xi_{\perp} = \begin{cases} \frac{10.56 \eta}{a^2} \frac{\mu^{1.531}}{(1-\mu)^3} & ; a = 6-10 [\mu\text{m}] \\ \frac{6.8 \eta}{a^2} \frac{\mu^{1.296}}{(1-\mu)^3} & ; a = 20-30 [\mu\text{m}] \end{cases}$$

Semi-empirical data (analytical relation fitted to experimental data for mono-valued fibre radii  $a$  and random fibre orientation):

$$\Xi = 4 \frac{\eta}{a^2} \left[ 0.55 \frac{\mu^{4/3}}{(1-\mu)} + \sqrt{2} \frac{\mu^2}{(1-\mu)^3} \right]$$

1 WinFLAG 2.3

File Add layer Frequency Sound incidence CONFIGURATION LAYER

TOP  
Limp mass  
Porous/Allard-Johnson  
Solid/Thin plate

Properties

Properties of Limp mass

User name = Limp mass  
Thickness = 1,25 mm  
Density = 2000 kg/m3  
Resistance = 0 Pa.s/m

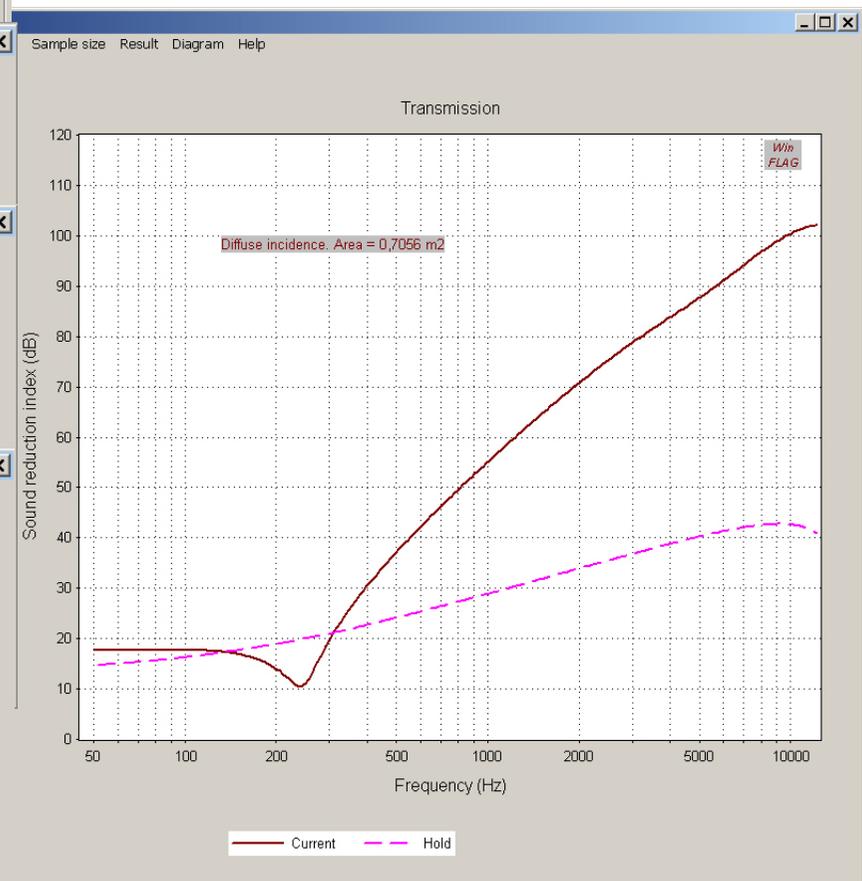
Properties of Porous/Alla...

User name = Porous/Allard-Johnson  
Thickness = 25 mm  
Resistivity = 38,5 kPa.s/m2  
Porosity = 95 %  
Tortuosity = 1,2  
Viscous length = 50 mju  
Termal length = 100 mju

Properties of Solid/Thin p...

User name = Solid/Thin plate  
Thickness = 0,8 mm  
Density = 7850 kg/m3  
E-modulus = 210 GPa  
Poissons number = 0,3  
Loss factor = 0,05

Data is OK Calculate



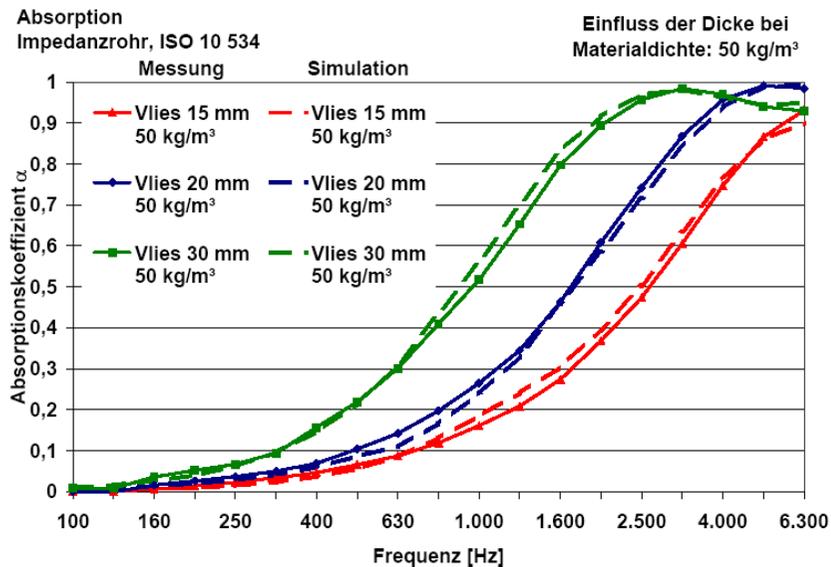
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# Vergleich von Prüfergebnissen und mathematischer Berechnung

## Luftschallabsorption im Impedanzrohr

- Materialien gleicher Dichte und variabler Dicke
- Gute Übereinstimmung Messung und Simulation

WinFlag Daten:  
 Modell: Porous Mechel  
 Absorption: Senkrechter Schalleinfall (0°)



Test no.  
 LAYER PROPERTIES  
 Layer no. : 1  
 Type: Porous/Mechel  
 Thickness: 14 mm  
 Resistivity: 16 kPa.s/m<sup>2</sup>  
 Porosity: 95 %

Layer no. : 2  
 Type: HARD WALL  
 No data

DUCT DATA  
 Duct half-width: 150 mm

WinFLAG Version 2.31

Test no.  
 LAYER PROPERTIES  
 Layer no. : 1  
 Type: Porous/Mechel  
 Thickness: 18 mm  
 Resistivity: 16 kPa.s/m<sup>2</sup>  
 Porosity: 95 %

Layer no. : 2  
 Type: HARD WALL  
 No data

DUCT DATA  
 Duct half-width: 150 mm

WinFLAG Version 2.31

Test no.  
 LAYER PROPERTIES  
 Layer no. : 1  
 Type: Porous/Mechel  
 Thickness: 27 mm  
 Resistivity: 16 kPa.s/m<sup>2</sup>  
 Porosity: 95 %

Layer no. : 3  
 Type: HARD WALL  
 No data

DUCT DATA  
 Duct half-width: 150 mm

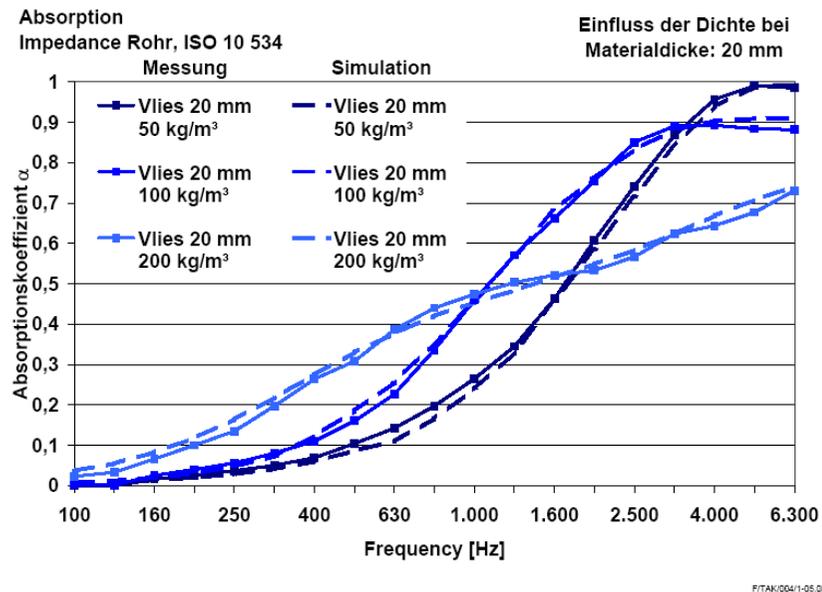
WinFLAG Version 2.31

# Vergleich von Prüfergebnissen und mathematischer Berechnung

## Luftschallabsorption im Impedanzrohr

- **Materialien gleicher Dicke und variabler Dichte**
- **Gute Übereinstimmung Messung und Simulation**

**WinFlag Daten:**  
**Modell: Porous Mechel**  
**Absorption: Senkrechter Schalleinfall (0°)**



Test no.  
 LAYER PROPERTIES  
 Layer no. : 1  
 Type: Porous/Mechel  
 Thickness: 18 mm  
 Resistivity: 16 kPa.s/m2  
 Porosity: 95 %

Layer no. : 2  
 Type: HARD WALL  
 No data

DUCT DATA  
 Duct half-width: 150 mm

WinFLAG Version 2.31

Test no.  
 LAYER PROPERTIES  
 Layer no. : 1  
 Type: Porous/Mechel  
 Thickness: 18 mm  
 Resistivity: 72 kPa.s/m2  
 Porosity: 92 %

Layer no. : 2  
 Type: HARD WALL  
 No data

DUCT DATA  
 Duct half-width: 150 mm

WinFLAG Version 2.31

Test no.  
 LAYER PROPERTIES  
 Layer no. : 1  
 Type: Porous/Mechel  
 Thickness: 18 mm  
 Resistivity: 256 kPa.s/m2  
 Porosity: 90 %

Layer no. : 2  
 Type: HARD WALL  
 No data

DUCT DATA  
 Duct half-width: 150 mm

WinFLAG Version 2.31

# Berechnung und Simulation akustischer Materialeigenschaften mit WinFlag

Informationen zu WinFlag:

**WinFlag Help:**

WinFlag\_231\WinFlag\_help\_v23.pdf

**WinFlag Prüfanweisung:**

...

**WinFlag Simulationspräsentation:**

...

**WinFlag Materialdaten:**

...

...

...

**Auswertungen für „Biot-Allard“-Parameter: Resistivity; Porosity; Tortuosity; ...**

...

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