Material Parameter Measurement (MPM) C4

Software Module and Accessory of the KLIPPEL ANALYZER SYSTEM
(Document Revision 1.7)

FEATURES

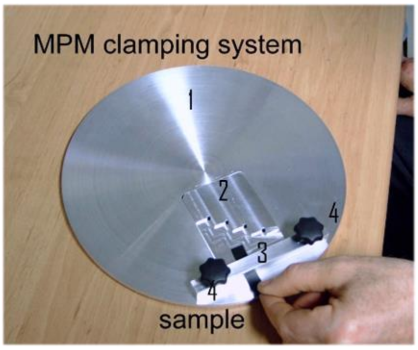
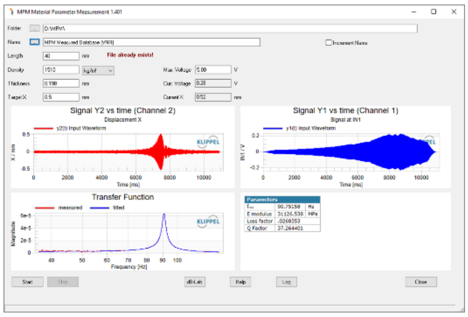
- Measure E modulus and damping
- Evaluate raw materials
- Specify loudspeaker parts more precisely
- Provide input data for FEA
- Find optimal materials
- Maintain consistent products

The material parameter measurement module (MPM) measures the Young's E modulus and the loss factor η of the raw material used for loudspeaker design. The vibration beam technique (ASTM E 756-93) is modified to be capable for measuring also soft materials such as thin foils of plastic, rubber and any kind of paper and impregnated fabric. After cutting 1 cm strips the probes are clamped on one side and excited pneumatically by using the suspension part measurement bench.

Article Number:	2500-200, 2500-210

CONTENTS:

1 Components of MPM Set

MPM Clamping Set	A special clamping set is provided to clamp the samples with a defined beam length. The clamping set comprises a round platform **(1)** with a rectangular opening, an upper beam **(3)** fastened by two screws **(4)** at the platform and an adjustment tool **(2)**. The adjustment tool has 5 slots of different length. After inserting the adjustment tool into the platform (right picture) the sample will be inserted into the slot and clamped by fastening the two screws. After removing the adjustment tool and placing the platform in the SPM measurement box the sample is excited pneumatically to the first bending mode.	
Material Parameter Software (*MPM Automation*)	A visual basic application is provided which allows to perform the measurements with a minimum user interface dedicated to this special measurement. The user provides the input parameter (length, density, thickness) and determines where the measurement results should be saved.	

2 Additional Components required

SPM Measurement Box ***Or*** **LST Bench**	The MPM can be realized cost effectively as an add-on of the suspension part measurement SPM. After removing the clamping part used for spiders and surrounds the remaining measurement box holds the MPM clamping platform. An adjustable laser guide holds the displacement laser sensor and a hole in the box is provided to measure the sound pressure inside the box. The clamping platform can easily put up in a horizontal position for charging but is used in a vertical position during measurement. The set consists of the cable for connecting the measurement bench to Klippel Distortion Analyzer.	 

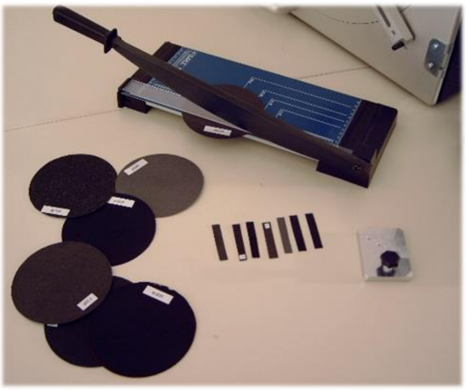
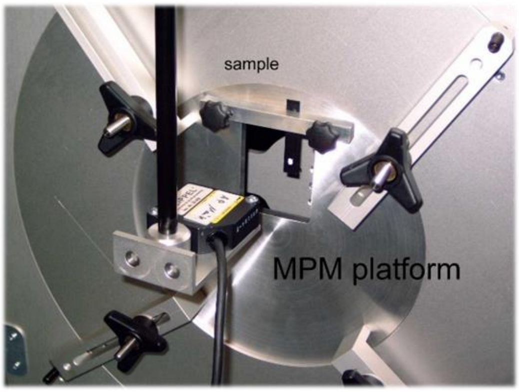
<table>
<tr><td>Measurement Platform</td><td>The Distortion Analyzer 1 or 2, or the Klippel Analyzer 3 may be used as the hardware to control the laser head and to perform the measurement.

Note: If you are using a Klippel Analyzer 3, an additional license dongle will be provided.</td><td>
</td></tr>
<tr><td>Sensor</td><td>A displacement laser sensor is required to measure the displacement of the material samples at the required precision.
For MPM standalone operation the Keyence IL-030 or IL-65 is recommend.
The Keyence LK-H52 sensor that is usually used with the KLIPPEL R&D System could be used as well.
The older Keyence LK-G32 sensor also, but with displacement limitations.
The ANR 1282 sensor is not recommended due to its higher noise level.</td><td>
</td></tr>
<tr><td>Additional Software</td><td colspan="2">The MPM uses the following software modules of the KLIPPEL R&D System
Transfer Function Module (TRF)
dB-Lab</td></tr>
<tr><td>Amplifier</td><td colspan="2">A power amplifier is required for performing the measurement. The amplifier should provide more than 50 W output power on 4 Ohm.</td></tr>
<tr><td>Microphone</td><td colspan="2">A quarter inch microphone is required for performing the measurement. The G.R.A.S. 40PP-S1 is the default microphone for MPM application. This cost-efficient microphone with a sensitivity of 10 mV/Pa can be connected directly to the IEPE powered MIC inputs of the Analyzer Devices. (Alternative Option: G.R.A.S. 40PP)</td></tr>
<tr><td>Computer</td><td colspan="2">A personal computer (not available at KLIPPEL) is required for performing the measurement.</td></tr>
</table>

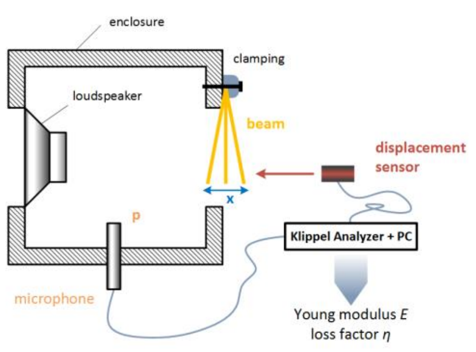
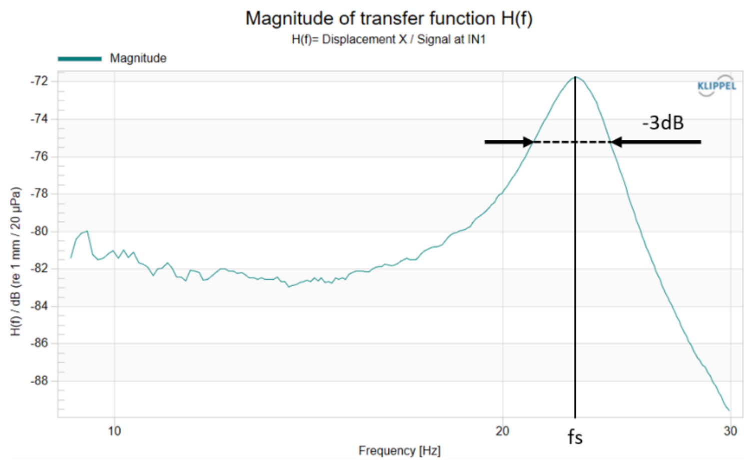
3 Objects of the Measurement

Material	This measurement technique may be applied to almost any material used in loudspeakers such as paper, rubber, plastic, fabric, metals and any compound materials. It is recommended to use samples cut from a plain sheet, plate or foil. Samples taken from spherical cones or surround roles are problematic because the curvature in the beam makes the beam stiffer causing higher values of the measured E modulus. Paper, plastics, metals or impregnated fabric which has been bended before should not be used at all. Many materials such as fabric are not isotropic that means the measured material properties depend on the direction of the cut. To verify the measured parameter values it is recommended to repeat the measurement with a different batch of the material, cut the samples in different direction and clamp the sample at a different beam length.

4 Measurement Procedure

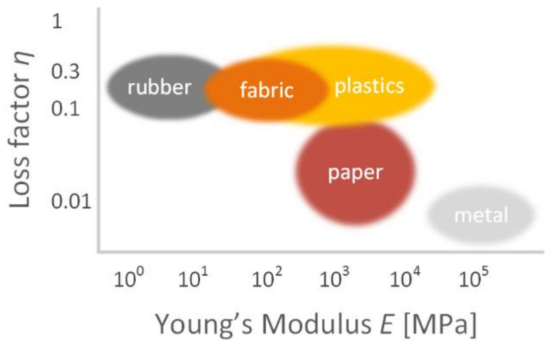
Cutting the Samples	The samples should be cut in small stripes 1 cm wide and 8 cm long by using a knife or a pair of scissors. It is important to have a constant width along the beam which can be ensured by using a plate shear.	
Measuring Density and Thickness	Measure with a high-precision scale the weight of the sample and determine the thickness of the sample. Calculate the density.	
Clamping	1) Insert the adjustment tool 2) Insert the sample into the slot giving the desired length of the beam 3) Fix the upper clamping beam 4) Remove the adjustment tool 5) Adjust the laser displacement sensor to the free end of the beam	
Start the Measurement	1) Start the visual basic application MPM Start.exe 2) Enter the geometrical data, density and the name of the sample 3) Press the start button	

5 Measurement Principle

<table>
<tr><td>Physics</td><td>The beam is excited pneumatically by a sine sweep generated by the TRF module. During the sweep the sound pressure P(f) and excursion X(f) are measured simultaneously. X(f) is achieved from a displacement sensor (laser), which is directly mounted on the test box to minimize vibration, offset and other errors. The sound pressure is measured with a microphone which is mounted in the measurement bench. Both sensors are powered by the Distortion Analyzer (DA2) or Klippel Analyzer 3 (KA3) hardware.</td><td>
</td></tr>
<tr><td>Material Parameters</td><td colspan="2">

The TRF module calculates the transfer function H(f) = X(f)/P(f) which is used to determine the modal resonance frequency f_s and 3 dB bandwidth Δf_{3dB}. From these values, the geometrical parameters of the beam and its mass the modal E modulus and loss factor η are calculated. The calculation is done by using the CAL-module.</td></tr>
</table>

6 Results

<table>
<tr><td>E Modulus
Loss Factor η</td><td>This measurement provides the E modulus and the loss factor η dynamically measured. It is recommended to present those measurement data together with the excitation frequency (identical with the resonance frequency of the first bending mode) and information about the ambient temperature and humidity.</td><td>
</td></tr>
</table>

Summary of Measurement Data

	A	B	C	D	E	F	G	H	I
1									
2	DUT	rho	l	d	E	n	Q	fs	xpeak
3		kg/m^3	mm	mm	MPa			Hz	mm
4	Sample 1	1243	30	0.1	4416.4087	0.080379	12.441009	33.8289573	1.0304
5	Sample 2	1243	30	0.1	2470.04352	0.07017	14.251126	25.2991702	0.271911
6	Sample 3	1243	30	0.1	2373.95739	0.070777	14.128961	24.8022129	0.278929
7	Sample 4	1122	30	0.1	1635.27595	0.11891	8.409719	21.6645635	1.031928
8	Sample 5	1122	30	0.1	1663.60581	0.12185	8.206801	21.8514179	1.032845
9	Sample 6	1122	30	0.1	1493.04214	0.120414	8.304698	20.7009575	1.019543
10	Sample 7	1170	30	0.1	793.460684	0.124132	8.055928	14.779485	1.020777
11	Sample 8	1170	30	0.1	795.488094	0.135455	7.382552	14.7983559	0.981182
12	Sample 9	1170	30	0.1	773.52546	0.121712	8.216132	14.5926416	1.008999

The most important results are usually stored in a txt file called summary.txt located in the folder where all the results of one measurement series are collected. This file can be viewed by a simple txt editor or exported to any table oriented post processing software (e.g. Excel®).

Database

All of the primarily data (sound pressure, displacement) and the calculated transfer response are stored in a database which can be viewed by *dB-Lab*. A detailed analysis may be useful to setup the system, check the SNR of the signals and to cope with a malfunction of the system.

7 Limits

Parameter	Symbol	Min	Typ	Max	Unit
Young's E modulus	E	0			MPa
Loss Factor	η	0.0001	0.1	1	
Q Factor (related to Loss Factor)	Q	80	20	0	dB
Resonance Frequency	f_s	20		200	Hz
Density	ρ	0	100		kg/m^3
Thickness	D	0.05	0.5		mm
Minimal Voltage of the Stimulus	U_{min}	0.0001	0.01		V
Maximal Voltage of the Stimulus	U_{max}		2	50	V
Target Displacement	X_{target}	0.01	0.2	2	mm
Length of the Beam	L	15		50	mm

Find explanations for symbols at:

http://www.klippel.de/know-how/literature.html

Last updated: December 01, 2023