RAAK Composites in Mechatronics

final presentation

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Kenniscentrum
Mechatronica

Fontys
Hogescholen

Contents

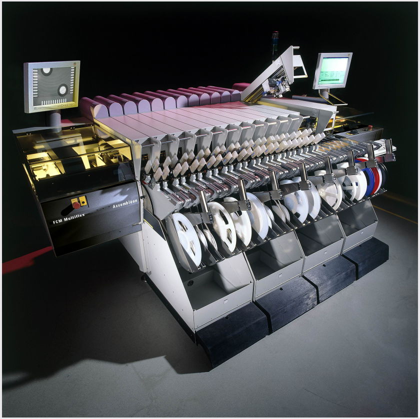
What is mechatronics?

Mechatronics

What is mechatronics?

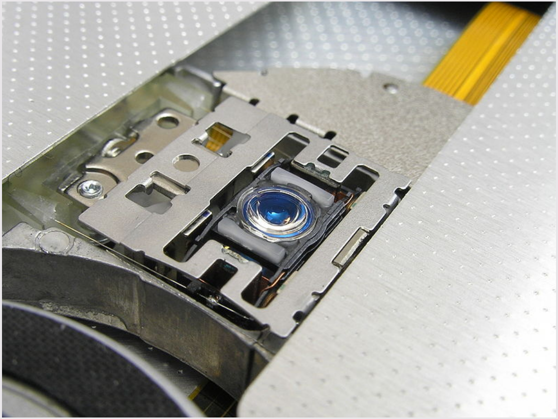
- Combination between MECHAnics and elecTRONICS
- Dynamical systems
- High speed
- High accuracy
- Robotics

Examples



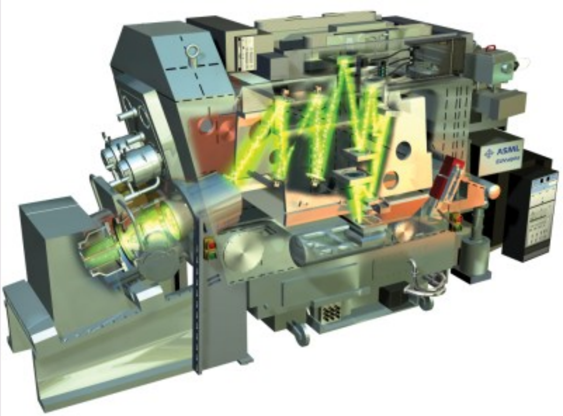
Mechatronics

Examples



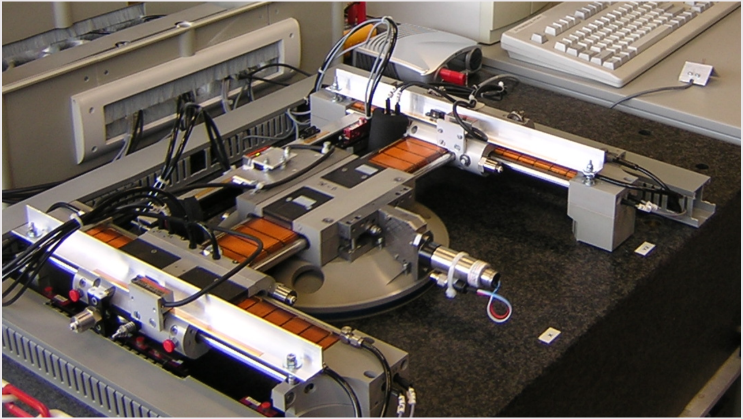
Mechatronics

Examples



Mechatronics

Examples



What is the mechatronics laboratory?

Mechatronics laboratory

What is the mechatronics laboratory?

- Laboratory within Fontys Engineering
- For students
- For companies
- Projects

Mechatronics laboratory

Competences?

- Mechanics
- Dynamics
- FEM
- Electronics
- Computer sciences
- Embedded
- Control engineering
- Robotics
- Vision
- Composites???

Composites in Mechatronics

CIM

How did it start?

- Project Paul and Paul: FCM system
- Need for light and stiff construction: Carbon fibre!
- Too little composite knowledge in mechatronics-land
- Together with companies: start of RAAK CIM

CIM

RAAK CIM: Company problems / wishes

- Properties of composites
- Designing in composites
- Calculations (FEM) with composites
- Examples

The project plan

Project Plan

INHolland

- Measurement system composites: static
- Properties of composites
- Design guide: production

Fontys

- Measurement system composites: dynamic
- Properties of composites
- Design guide: design and calculations
- Demonstrators

Project Plan: Cases

- Measurement system composites: dynamic
- FEM and composites
- Laminate calculation program
- Demonstrator: Air-hockey robot (TMC)
- Demonstrators: Philips
- Demonstrator: Composite leaf springs
- Design guide

Measurement system

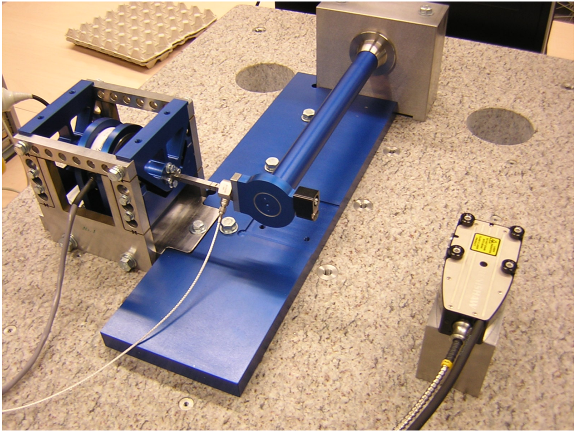
Cases: Measurement system

requirements

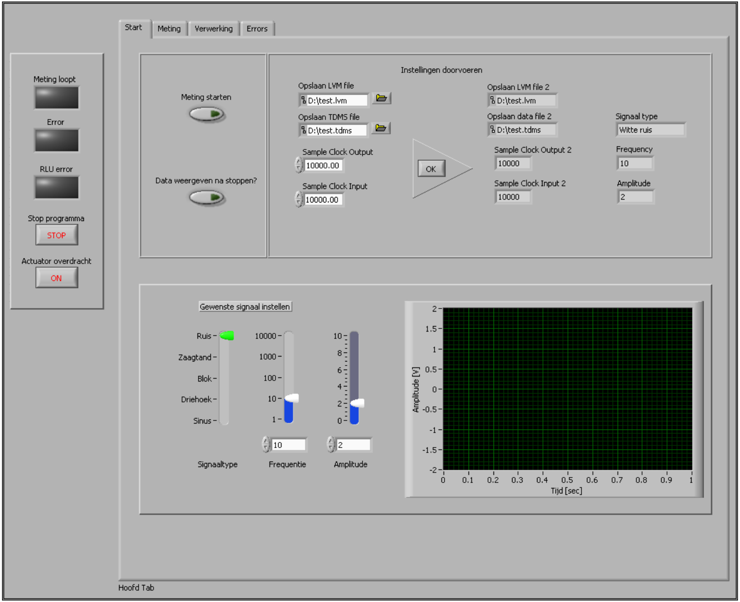
- measure stiffness and damping
- measure degradation
- dynamic measurements (1 kHz)

Cases: Measurement system

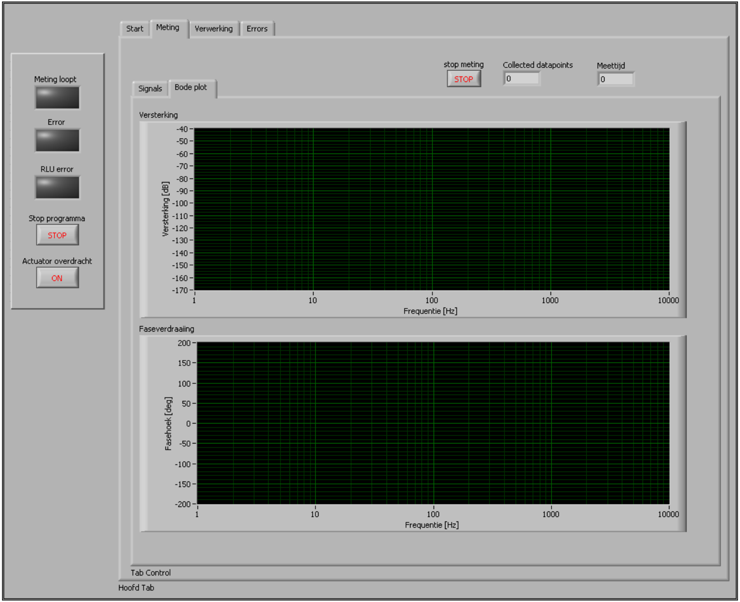
- Magnetic actuator
- Flexure hinges
- Force sensor
- Laser-interferometer



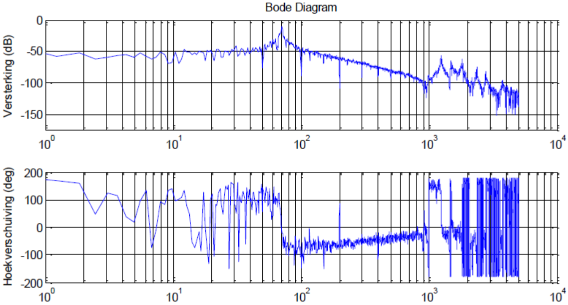
Cases: Measurement system, labview interface



Cases: Measurement system, bode plot



Cases: Measurement system, results



- Stiffness too low, investigation needed

FEM and composites

Cases: FEM and composites

FEM with steel/aluminium?

- design geometry
- lookup E, G, ν
- boundary conditions
- solve
- improve geometry if necessary

FEM with composites?

- design geometry
- fibre and matrix properties
- design layup $\rightarrow$ E, G, ν
- ANSYS: E_1, E_2, E_3, G_{12}, G_{23}, G_{31}, ν_{12}, ν_{23}, ν_{31}
- layup in ANSYS: bulk, pre-integrated or layers?
- ...

Cases: FEM and composites

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- ...

Cases: FEM and composites

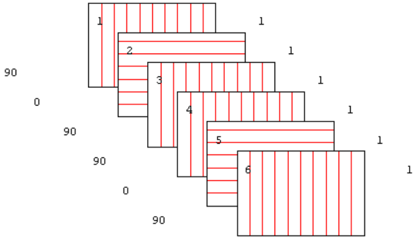
requirements

- use FEM only for global idea of possibilities
- low entry level
- focus on ANSYS

First result: guide for ANSYS APDL (Classic)

Composieten in ANSYS

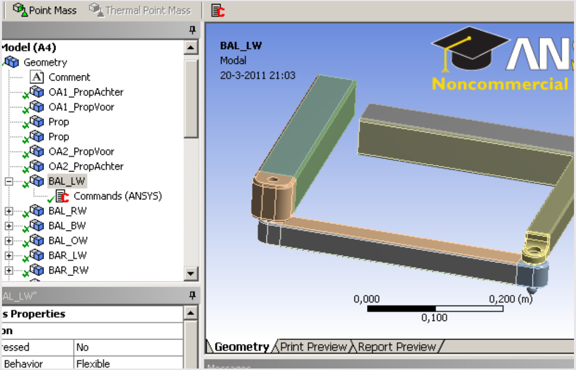
Een handleiding voor het gebruik van ANSYS Classic en Ansys Workbench bij het modelleren van composietmaterialen.



- ANSYS APDL
- focus on meshing

Cases: FEM and composites

real design case: Air-hockey robot



- ANSYS Workbench
- material properties from laminate program

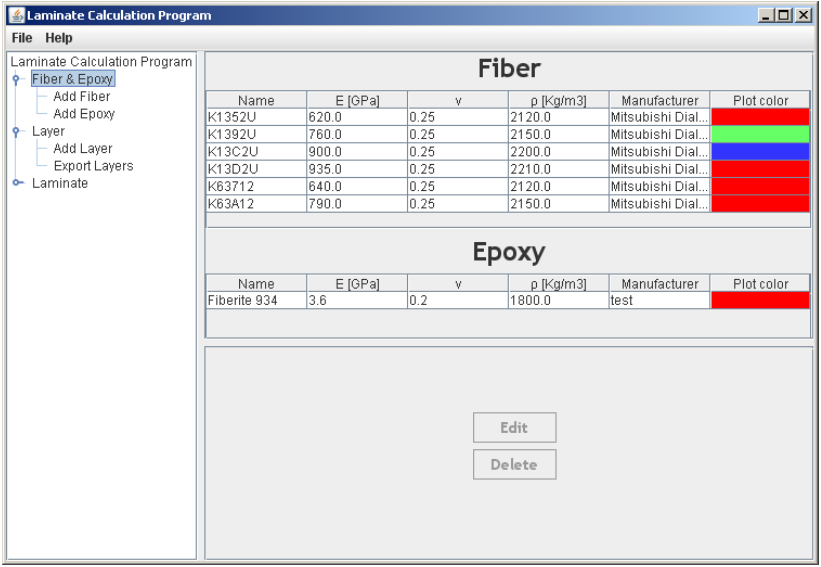
Cases: FEM and composites

Final step: Design guide

- Work in progress
- Laminate program
- FEM tutorial
- Use demonstrators as examples

Laminate calculation program

Cases: Laminate calculation program



Cases: Laminate calculation program

Step 1: fibre and matrix

Fiber

Name	E [GPa]	ν	ρ [Kg/m3]	Manufacturer	Plot color
K1352U	620.0	0.25	2120.0	Mitsubishi Di...	
K1392U	760.0	0.25	2150.0	Mitsubishi Di...	
K13C2U	900.0	0.25	2200.0	Mitsubishi Di...	
K13D2U	935.0	0.25	2210.0	Mitsubishi Di...	
K63712	640.0	0.25	2120.0	Mitsubishi Di...	
K63A12	790.0	0.25	2150.0	Mitsubishi Di...	

Edit

Delete

K13C2U

Mitsubishi Dialead

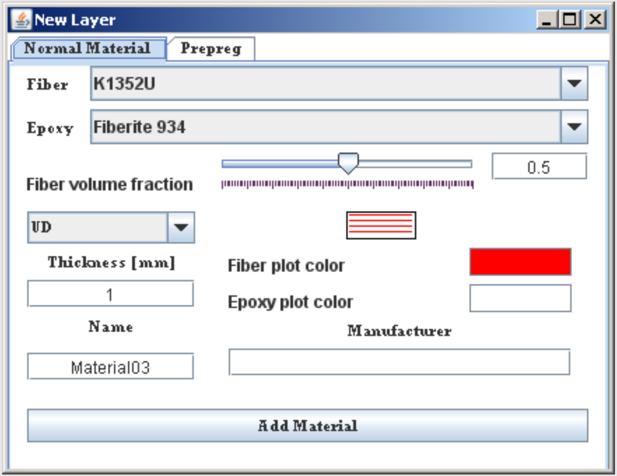
E [GPa]	ν	ρ [Kg/m^3]
900.0	0.25	2200.0

α [°C^{-1}]

0.0

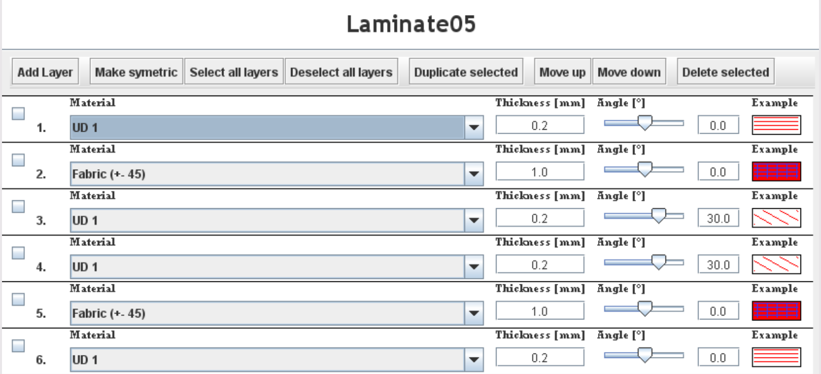
Cases: Laminate calculation program

Step 2: layer (prepreg)



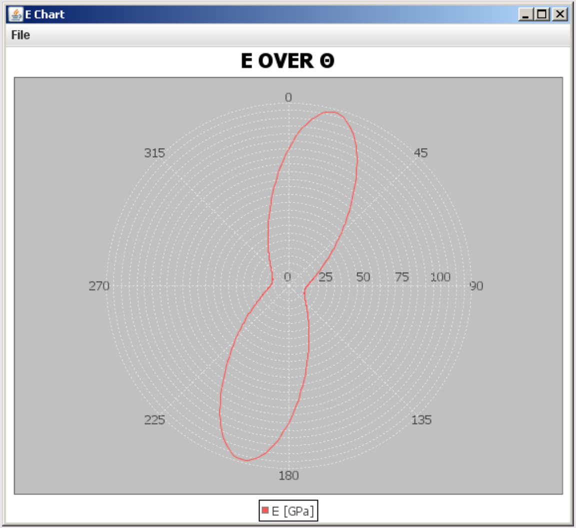
Cases: Laminate calculation program

Step 3: laminate

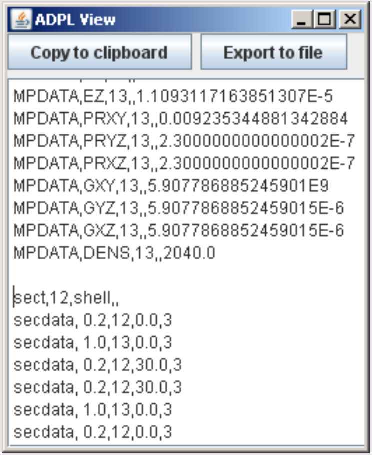


Cases: Laminate calculation program

Step 4: analyze



Step 5: export to ANSYS

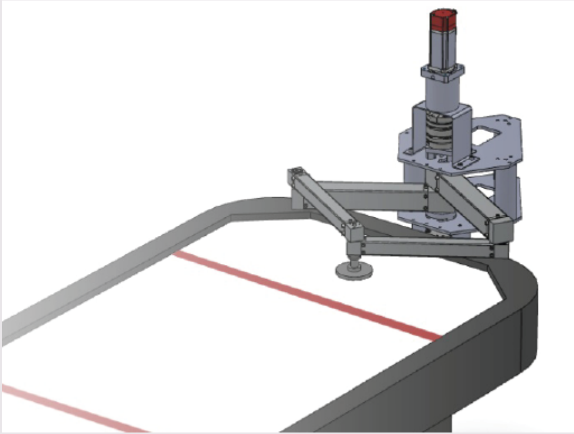


- orthotropic material constants per layer
- section data (layers)
- ABD matrix
- material constants total laminate (bulk)

Demonstrator: Air-hockey robot

Cases: Demonstrator: Air-hockey robot

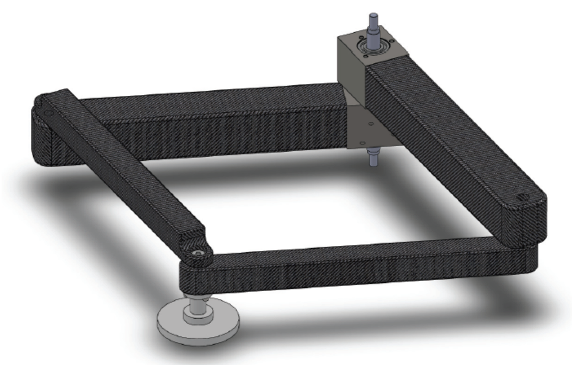
Original robot



- Steel arms
- desire to make arms lighter and stiffer

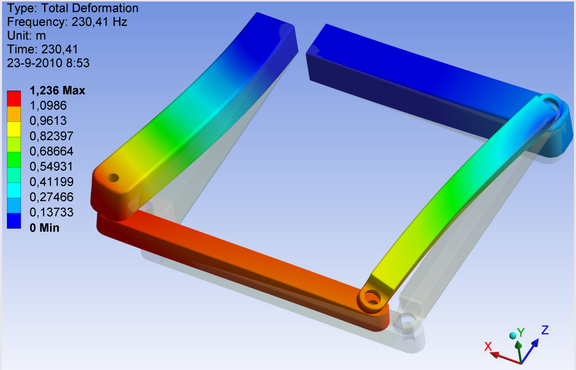
Cases: Demonstrator: Air-hockey robot

New design



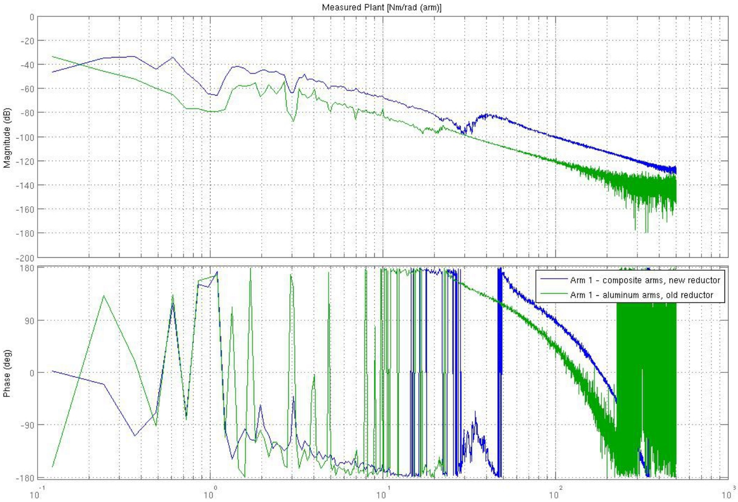
Cases: Demonstrator: Air-hockey robot

New design



- Higher natural frequency: 84 $Hz \rightarrow 230\ Hz$
- Reduction of mass-inertia: 0.60 $Kg\ m^2 \rightarrow 0.23\ Kg\ m^2$
- Increased stiffness: 0.66 $kN/mm \rightarrow 1.6\ kN/mm$

Cases: Demonstrator: Air-hockey robot



- Better performance
- also cheated a bit: new reductor

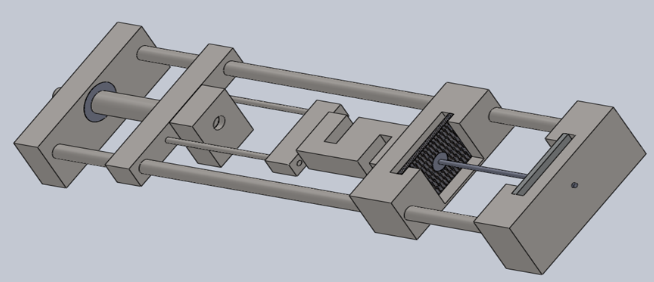
Demonstrators: Philips

Cases: Demonstrators: Philips

requirements

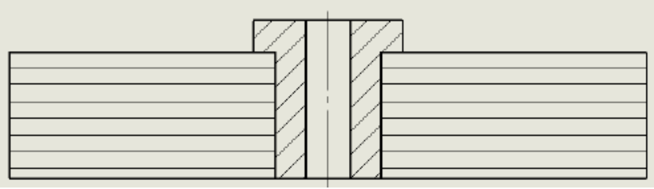
- Show possibilities with composites
- Overcome difficulties (inserts, designing)
- Try to keep it fun

Cases: Demonstrators: Philips, inserts



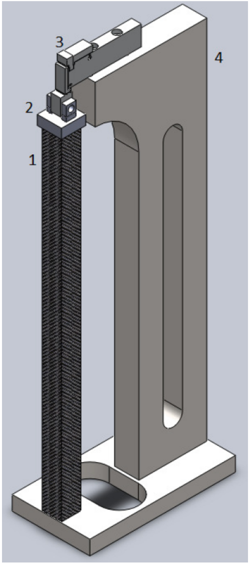
- show strength of inserts
- measure strength of insert
- design inserts

Cases: Demonstrators: Philips, inserts



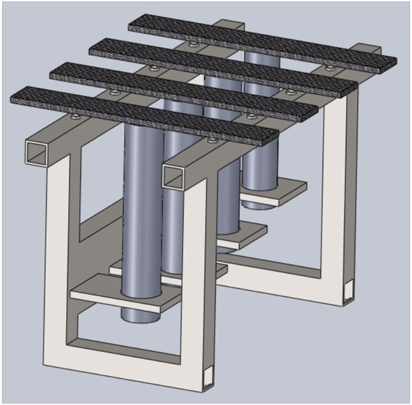
- Rule of thumb: use shear

Cases: Demonstrators: Philips, thermometer



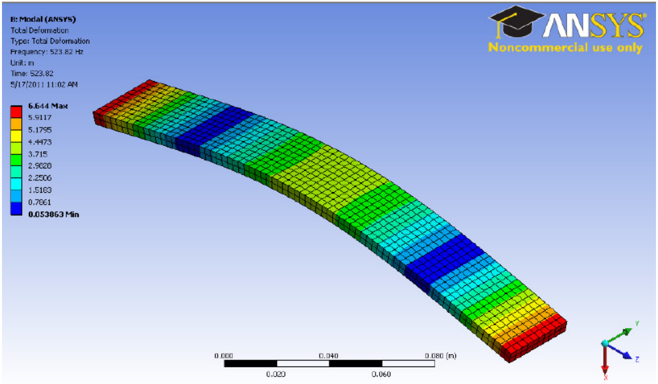
- Show low CTE

Cases: Demonstrators: Philips, xylophone



- Design natural frequency
- Different tones, with same size plates

Cases: Demonstrators: Philips, xylophone



- Use laminate program
- Use ANSYS
- If even a student can do it...

Cases: Demonstrators: Philips

Some remarks

- Production is harder than calculations
- Calculations can be relatively easy
- FEM (ANSYS) and composites can be relatively easy

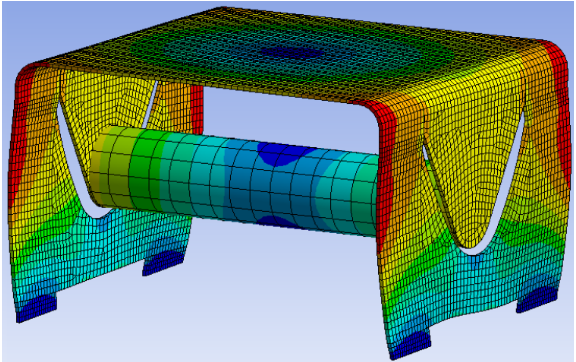
Demonstrator: Composite leaf springs

Cases: Demonstrator: Composite leaf springs

requirements

- Light and stiff straight guidance
- Leaf springs from composites
- Design with hand calculations, laminate program and ANSYS

Cases: Demonstrator: Composite leaf springs



- High natural frequency (650 Hz)
- High stiffness
- Light weight
- Unfortunately, no real product
- Fortunately, a lot of knowledge about designing composites, FEM

Design guide

Cases: Design guide

requirements

- For mechanical engineers with little knowledge about composites
- Hand calculations
- FEM
- Worked out examples
- Online available

Cases: Design guide

- Work in progress

What do we have

- Worked out examples
- A lot of theoretical/mathematical stuff (too much)
- Laminate program (Beta status)
- FEM/composite knowledge from different sources

- Needs to be put in a usable format

Conclusion

Conclusion

Realized

- Demonstrators
- FEM and composites
- Measurement system (needs some work)
- Worked out examples

Needs to be done

- Design guide (material is available)
- Material properties (setup is available)
- Finish measurement system and laminate program