QuickField for teaching

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Abstract - At the given stage of development of the technics, one of the prominent aspects of preparation of engineers is the modern software applied in educational process.

I. Problem on heat transfer

A heat sink is a metal block with fins that sits on top of electronic components to cool them. Set up a steady state heat transfer problem with a single fin 3 mm thick by 20 mm long (and deep in the Z direction) or download the zip file *heattransfer.zip*. Remember to pay attention to the filenames defined in the problem *.pbm* file.

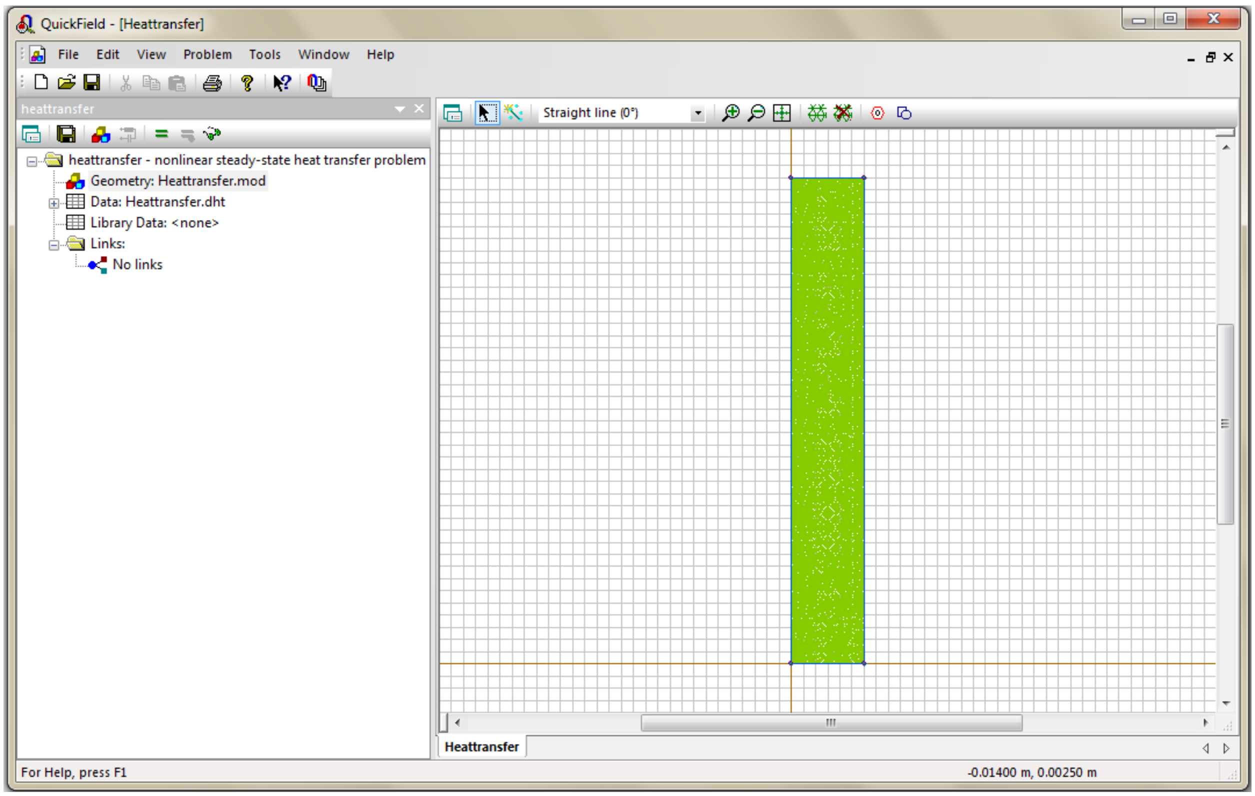


Fig. 1. Considered geometry

Set one end (bottom) to have a heat flux in from the electronics of 10 Watts/cm^2 and the other end to have zero heat flux. The surrounding temperature is 300 K.

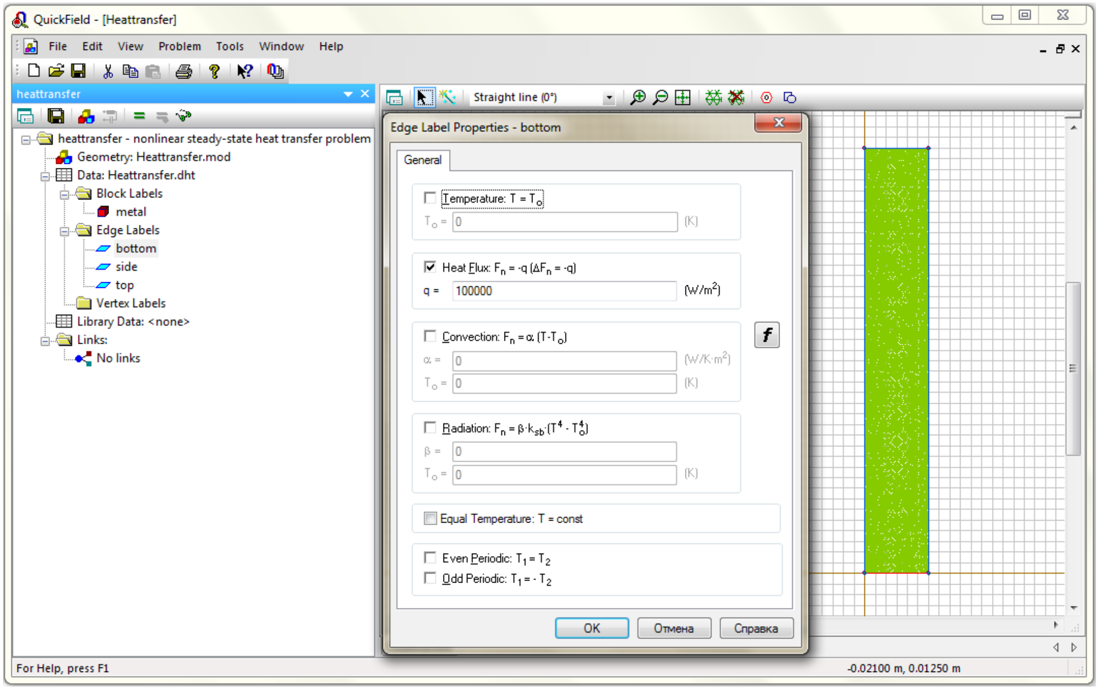


Fig. 2. Edge label properties - bottom

Heat can be lost from the sides by convection and radiation. Still air convection will remove heat at about 10 Watts/m^2/K per degree of temperature difference to the air. Forced air convection will remove 100 Watts/m^2/K. Radiation into air is calculated by Stefan's law and depends on the 4th power of temperature difference. A black body has a coefficient β of 1.

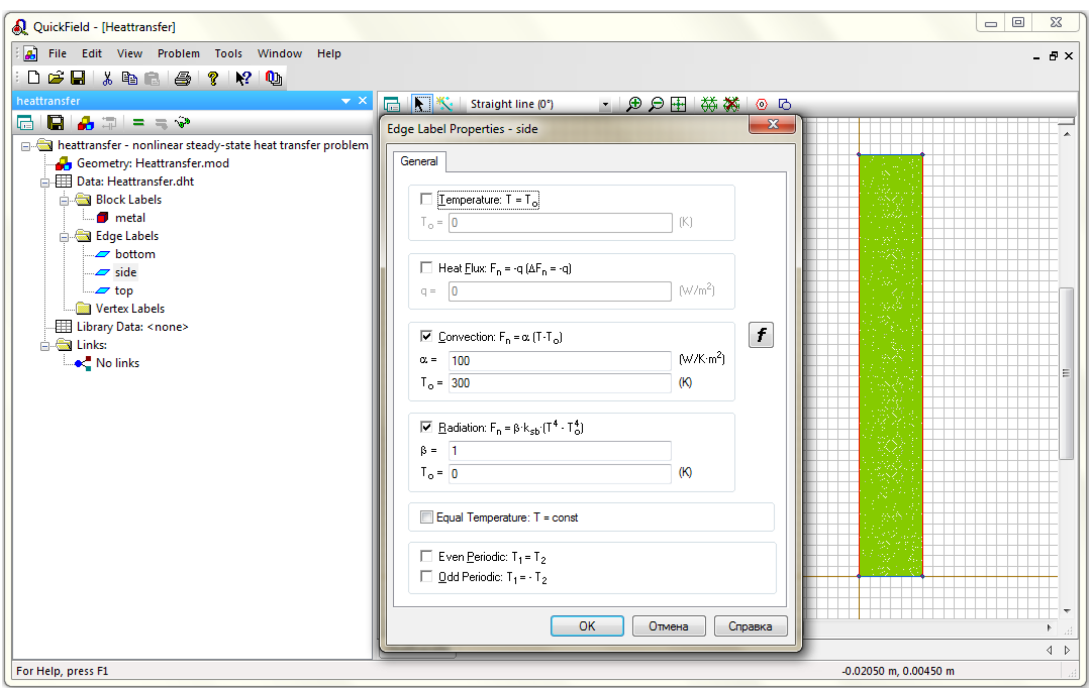


Fig. 3. Edge label properties - side

II. Problem on thermal shock

Fracture can occur because one material is hot and expands locally or because two materials expand differently.

The Quickfield file *Thermalshock2* has a bar made of two glass zones (actually 3 zones, but two are the same). This should be a plane stress problem with no z-axis stresses because otherwise the expansion will generate z-direction forces. Let us call them zone 1, 2 and 3 left to right. The constraints are x and y at the bottom right and x at the top right vertices.

You can picture this as a thin sheet of glass covering another glass or a metal, perhaps an enamel coating layer like you get on a kitchen stove.

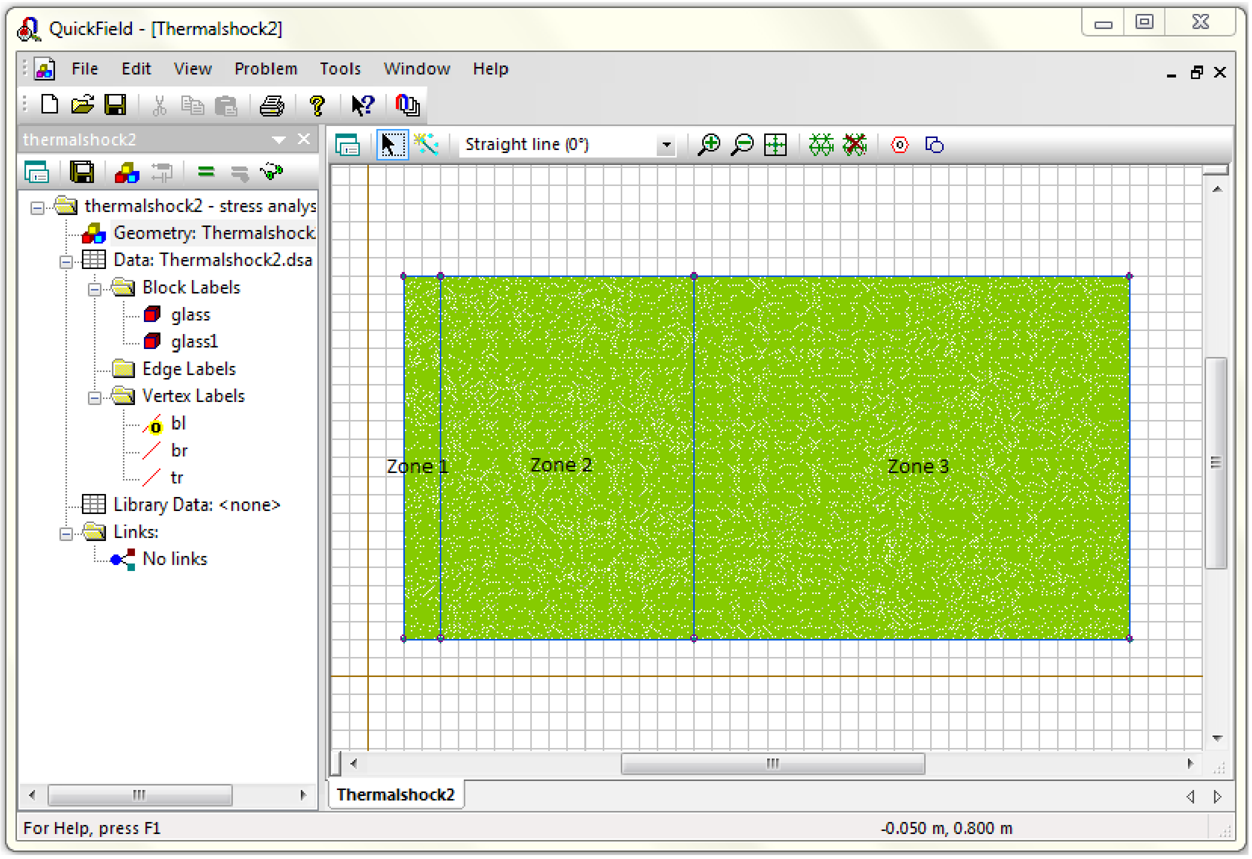
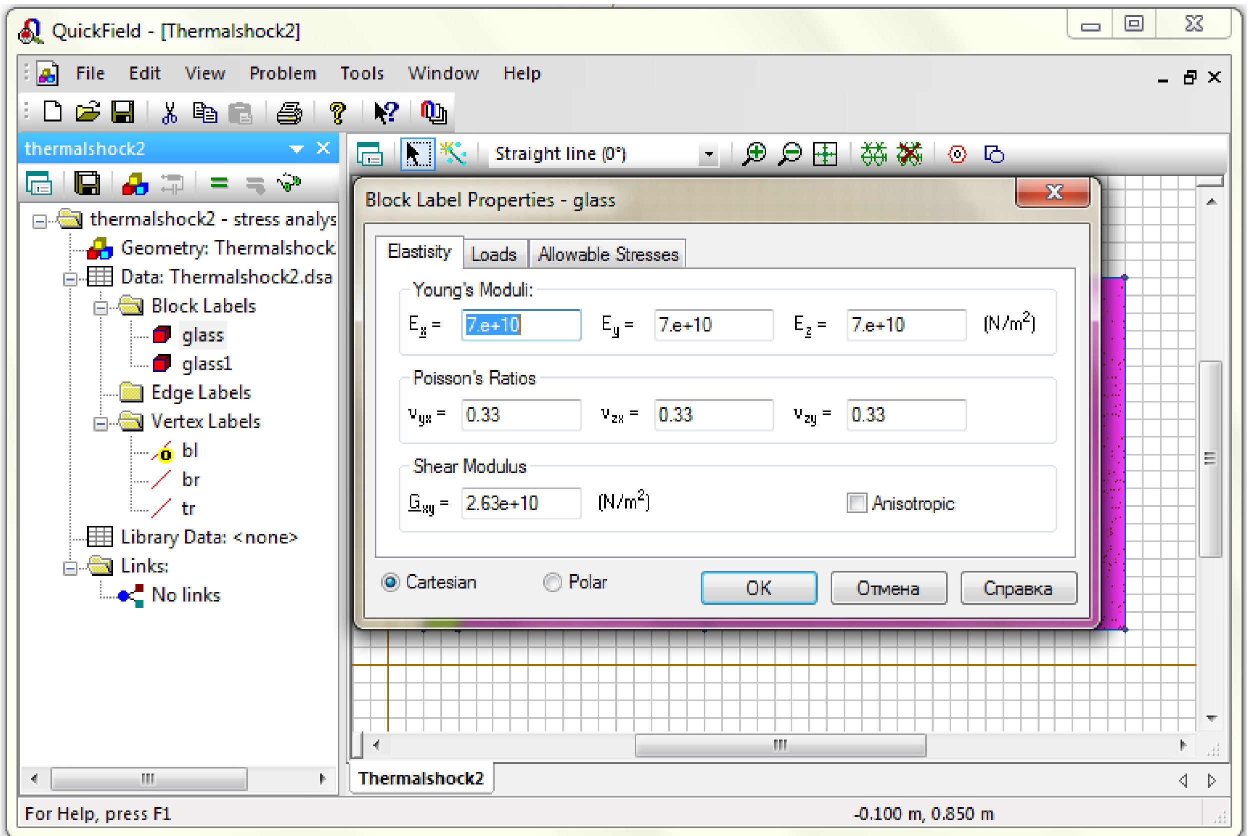


Fig. 4. Considered geometry

Give both glasses 70 GPa moduli, 0.33 Poisson's ratios. Set up the thinner left hand one Zone 1 with a thermal expansion coefficient of $2{\cdot}10^{-6}$ 1/ ^{o} C and the r ight hand large sections zones 2 and 3 with a thermal expansion coefficient of $5{\cdot}10^{-6}$ 1/ ^{o} C. There are no external loads but a temperature change can be applied so that stress develops.



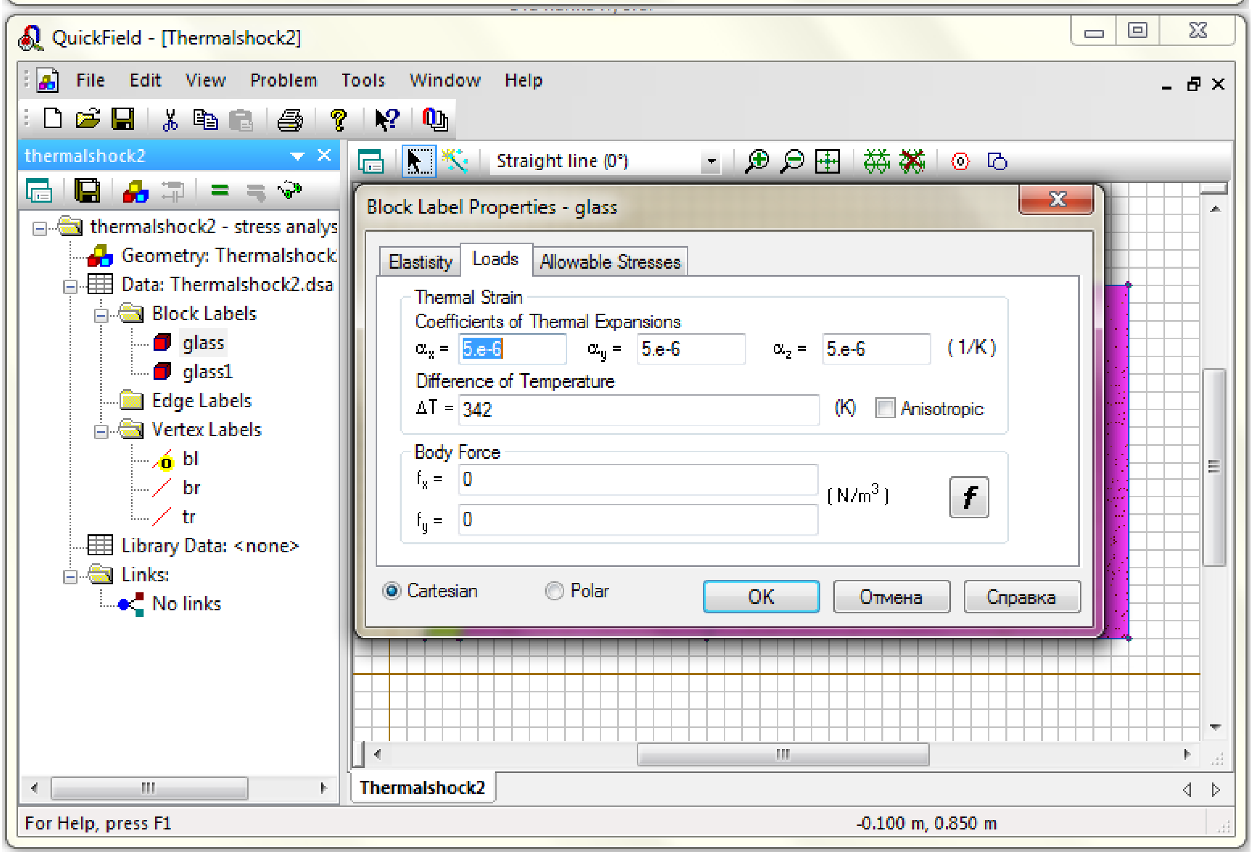


Fig. 5. Block label properties

Give both a temperature difference of 100 ^{o}C, meaning that the whole thing is heated by 100 ^{o}C. You will see that the expanding glass is compressed and the low coefficient glass is in tension at the interface. You should see a maximum y-axis tensile stress σyy develop of about 13MPa (15MPa von Mises stress) in the thin section while the thick section is mostly at low stress.

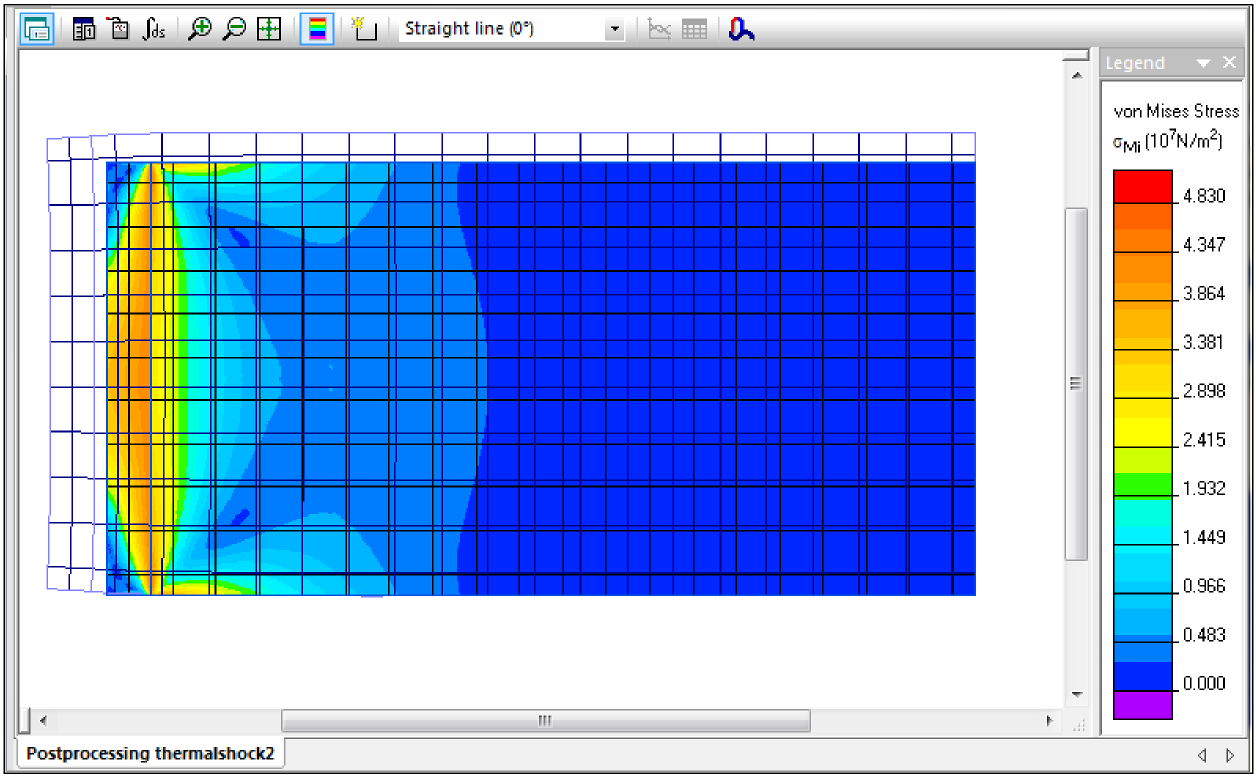


Fig. 6. Postprocessing window

The question is what uniform temperature increase leads to the combined body breaking (assuming no reverse stresses are left over from when it was cooled during manufacture). For the failure criterion, we will say that the strength of the glass in tension is 50 MPa and so the maximum tensile stress should be less than 50 MPa.

You can download simulation files at

http://quickfield.com/publications/quickfield_for_teaching.htm

Free Student QuickField is available at

http://quickfield.com/free_soft.htm