# Evaluating Thermo-Mechanical Stress on a Sensor Integrated Workpiece Using COMSOL Multiphysics

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**Introduction**: Thin film sensors can be integrated in a workpiece material to measure in-situ parameters in a grinding process. However, sensor acts a foreign body to the material and adds discontinuity which disturbs its homogeneity. This can lead to measurement inaccuracy. To calibrate the measurement a COMSOL simulation has been done. A comparison is made between the measured stress in a homogenous workpiece and in a workpiece that has an integrated sensor inlay, either glued or soldered to it.

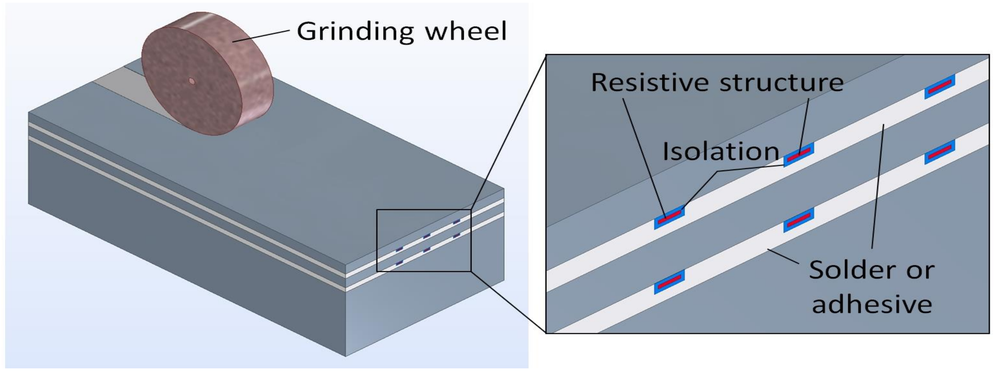


**Figure 1**. Schematic of sensor integration in steel workpiece

**Computational Methods**: The structural mechanics module was used to analyze a 2D model of both workpiece. Two models to calculate the in-plane stress and the heat flux entering the workpiece were built separately. Both models were coupled using the thermal stress module to include the effect of temperature on the measured stress.

To differentiate between the homogenous and the sensorial steel, Parametric Sweep function was used on the Young's Modulus and thermal expansion co-efficient of steel, solder, and glue.

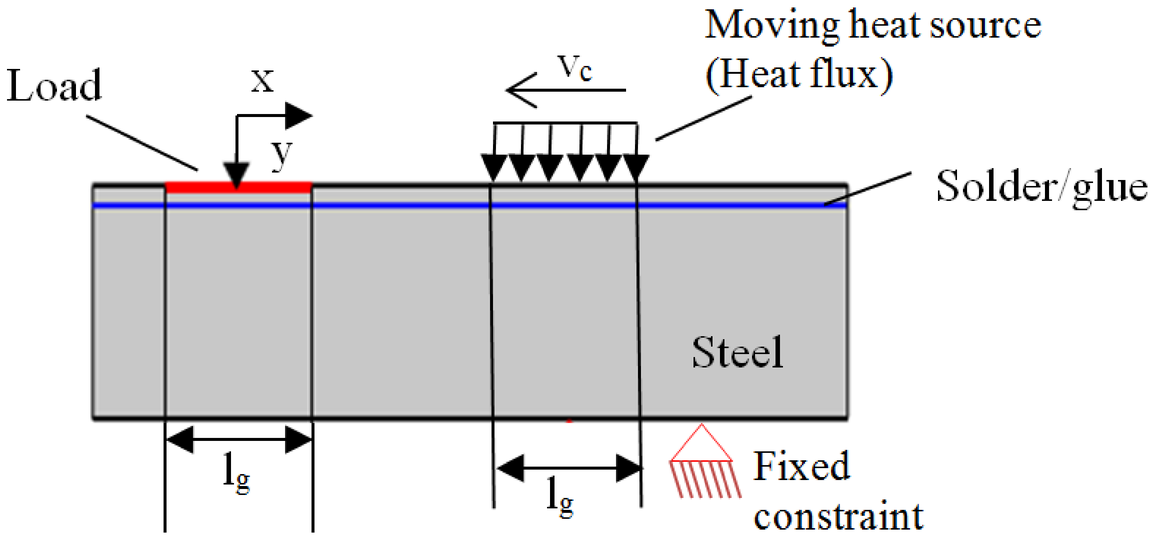


**Figure 2**. Geometry and model set-up. '$l_g$' is the contact length of the grinding wheel and $v_c$ indicates the feed. The bottom surface is at room temperature. Not to scale.

**Results**: Stress tensor in x-y plane due to combined mechanical and thermal effect of grinding is shown for three different workpiece. The deviation at 1.8 mm below the top surface where the sensor is embedded is greater in case of glued inlays as compared to soldered ones.

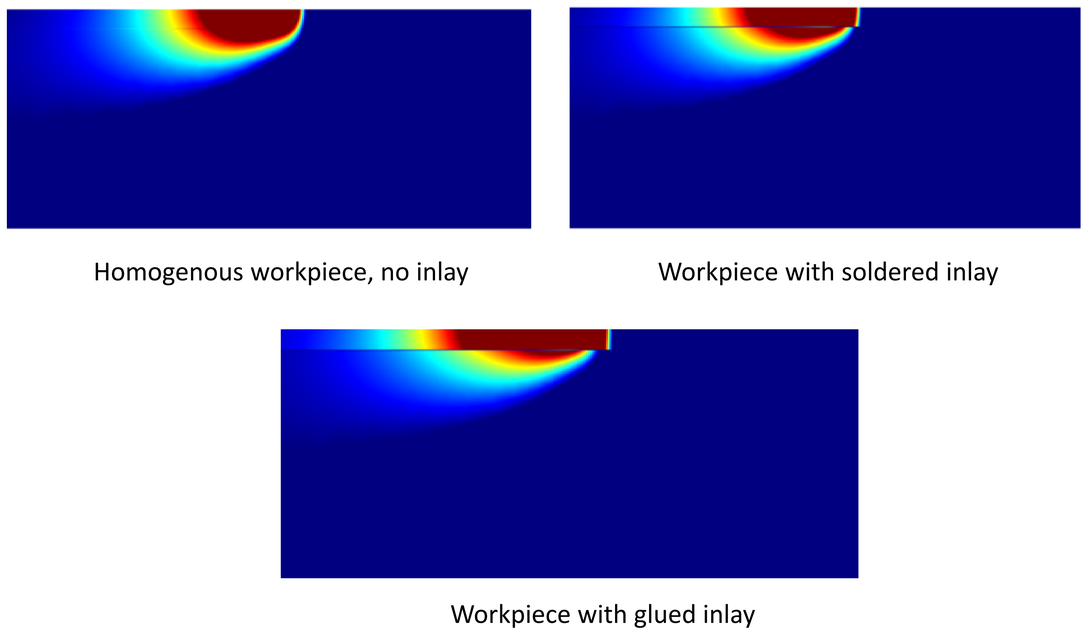


**Figure 3**. Stress tensor in x-y plane

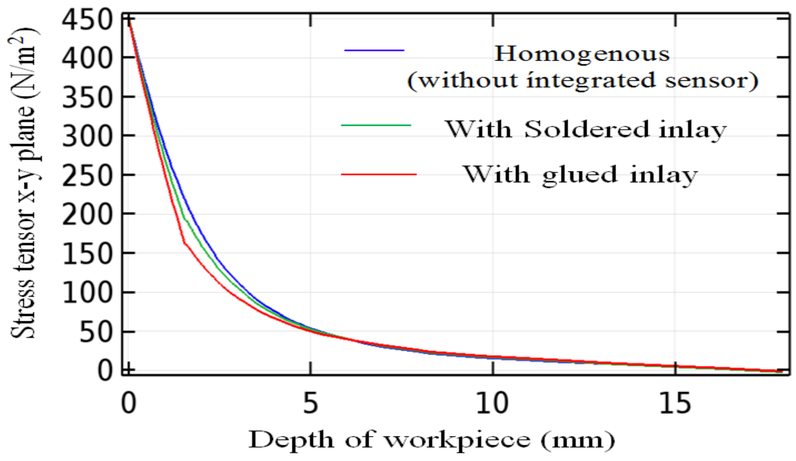


**Figure 4**. Plot of stress tensor in x-y plane along the depth of the workpiece.

**Conclusions:** Despite variations in the measurement signal, the range remains the same for all three cases. Thus by calibrating the measured output, a reproducible measurement can be obtained by integrating sensors using solder or glue. The latter is simpler to process and is cost-efficient.

## References:

1. Walter Lang et.al., From embedded sensors to sensorial materials – The road to function scale integration, Sensors and Actuators A 171 3-11 (2011)
2. Andreas Tausendfreund et.al., Systems for locally resolved measurements of physical loads in manufacturing processes, CIRP Annals-Manufacturing Technology 64 495–498 (2015)

Excerpt from the Proceedings of the 2015 COMSOL Conference in Grenoble