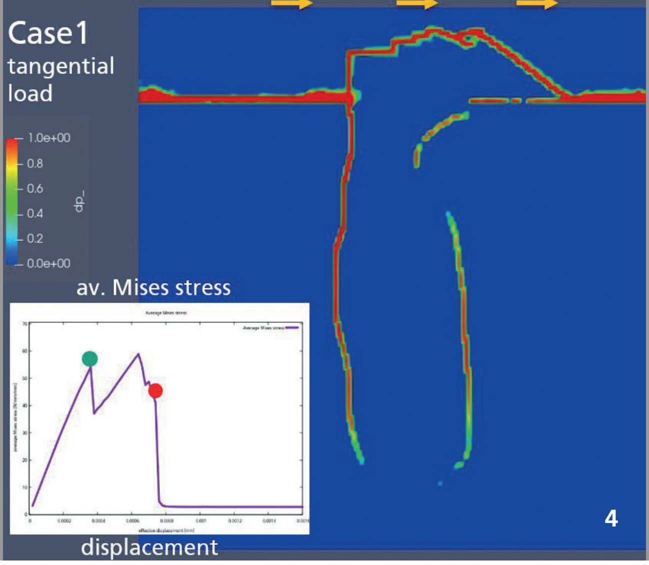

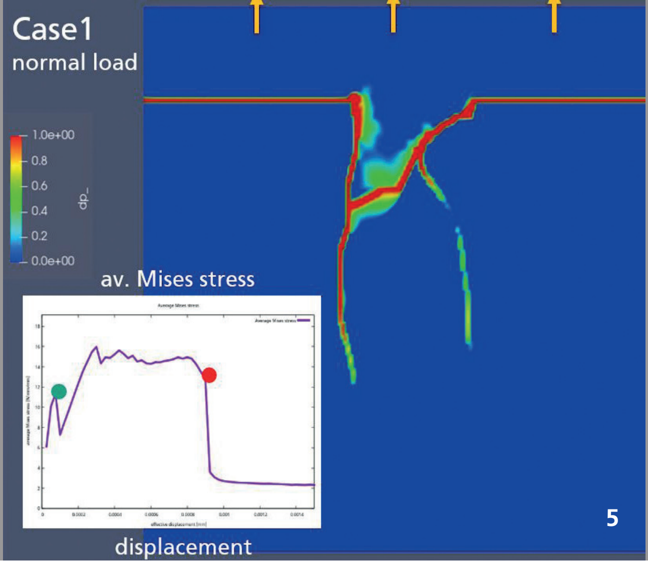

SIMULATION OF THE BONDING OF METAL-PLASTIC COMPOUNDS

Task

The industry is increasingly using material joints made of plastic and metal in lightweight construction or assemblies made of hybrid materials. Metals are usually applied, however, in places where high mechanical loads are present. Depending on the requirements, many components can be made of plastics, which have the advantage of being lighter. The challenge of combining such materials is often the joining technology. Bonding them with lasers raises questions, however, concerning adhesive strength. The interface between metal and plastic plays an important role and is defined by the shape of the metallic joining partner to be structured beforehand.

Method

Laser-beam bonding consists of two manufacturing steps, namely structuring the metallic joining partner and heat conduction joining. By simulating the structuring of a metal surface and evaluating the image of the experimental results, Fraunhofer ILT can provide input variables for calculating the strength of a joint. When the mechanical properties of metal, interface and plastic are combined and then characterized as linear elastic, orthotropic linear elastic and nonlinear hyperelastic, the behavior of the joint under load can be determined and calculated numerically. Furthermore, when the mechanical properties of a single structural element are calculated as a »Representative Volume Element RVE«, these properties can be transferred to more complex structures. For example, the properties of a single line can be used to calculate the properties of multiple or crossed lines.

Results

The depth, width and undercut of the structured surface of the metal are relevant features for designing the geometric shape of the metal-plastic interface and, thus, determine the achievable strength as well as the behavior during failure. The results for loading in the tangential (Fig. 4) and normal directions (Fig. 5) help us fundamentally better understand the dominant influence of the strength of the plastic as well as the geometric shape of the structured metal surface. Furthermore, they establish criteria for determining the material combinations and structural parameters.

Applications

The mechanical simulation approach can be transferred to a wide variety of layered (orthotropic) structures, such as assemblies containing electrically conductive and electrically insulating parts, or layers for thermal insulating turbine components.

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4 Onset of failure (green) and fracture (red) under tangential loading.

5 Failure under load in normal direction (arrows).