Numerical and experimental analysis of the thermally induced damage in remote laser cut carbon fiber reinforced polymers

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ABSTRACT

In cutting technologies for fiber reinforced polymers, remote laser cutting plays a special role because it can minimize the drawbacks of other laser cutting methods, e.g. frayed cutting edges, caused by the high heat input of the laser. It allows for precise cutting results even for high spot velocities and sharp edges, which facilitates a reduction of the heat input and thus decreased thermal damages. For a reliable structural analysis, it is necessary to quantify these damages and its possible effects on static and fatigue failure have to be determined.

In this contribution the material model Pinho et al. [3] is used to describe the static damage behavior. Compared to simpler failure models, this material model is characterized by physically based failure criteria for the different damage modes. In the first part of this presentation, the parametrization of the material model is outlined, whereat the focus is on tensile and shear failure modes. In order to determine stiffness and strength, tensile tests were performed and used for the validation of the simulation model.

In the second part of this contribution, a model to describe and analyse thermal damage caused by laser cutting is presented. The dimensions of the damaged area are taken from polished micro sections of the material around the edge. A review on the damaging effects of the heat input in FRP caused by laser cutting can be found in [2]. The spatial distribution of the damage in the specimen depends on the temperature field caused by the laser and is described as a function of the distance between a material point and the laser cutting edge. This predefined material degradation is modelled with the parameters of the static damage model, which allows for a mapping of the thermal effects to the failure modes and a separated modelling of the different effects. As an example, comparative tensile tests of water jet and laser cut open hole specimens, first presented in [1], are simulated. The advantage of these specimens is the predefined localization of damage at the cutting edge of the holes, which allows a direct comparison of the cutting technologies due to the controlled heat input at the failure area around the hole.

REFERENCES

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