Simulation of Self-Healing Processes in Microcapsule Based Self-Healing Polymeric Systems

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ABSTRACT

Self healing materials are becoming more and more important for the construction of mechanical components due to their ability to detect and heal failures and cracks autonomously. Especially in polymers and polymer-composites, where the component can loose a high rate of strength and durability due to micro cracks, those damages are nearly impossible to repair from outside. Thus, self healing ability is a very effective approach to extend the lifetime of polymer-made components.

In view of the numerical simulation of such self healing effects we consider the microencapsulation approach [1] and develop a thermodynamically consistent macroscopic 4-phase model within the theoretical framework of the Theory of Porous Media (TPM) [2, 3]. The model consists of the following different phases: solid (matrix material), liquid (healing agents), healed material and gas (cracks and damaged material). The increase of damage, is driven by a discontinuous damage evolution equation. Furthermore, a mass exchange between the liquid-like healing agents and the solid-like healed material, i.e. the change of the aggregate state from liquid healing to solid healed material, describes the healing process. The onset of the healing process is associated with the break open of the microcapsules in connection with the subsequent motion of the liquid healing agents. For simplification of the model it will be assumed that the motion of the solid material, the liquid-like healing agents, and the solid-like healed material are all equal except at an initial solid motion. The initial solid motion is the accrued solid motion before the onset of the healing process. Numerical examples of the simulation of healing processes in polymers and polymer-composites, as well as the micromechanical damage behavior of the self-healing microstructure, are presented in order to show the applicability of the model to simulate damage and healing processes.

REFERENCES

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