MODELLING THE THERMAL RUNAWAY DURING THE STABILIZATION PHASE OF THE CARBON FIBER PRODUCTION USING MICROWAVE HEATING

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The production of carbon fibers based on Polyacrylonitrile (PAN) precursor fibers is an energy intensive process. The final material costs are not competitive if compared to the production of steel or aluminum even though the mechanical properties are superior [1]. A solution for a more energy efficient production might be the introduction of microwave heating into the production process. A theoretical model for the first production step of the carbon fiber production, the stabilization phase around 260 °C, is set up to get a better understanding on the microwave heating and the reaction kinetics. The heat generated by the exothermic reactions is included, as well as, the change in the absorbed microwave power due changes in the dielectric loss. The influence of the strong rise of the dielectric loss with higher temperatures [1] can be increased or reduced by the use of a hybrid mode with a heated air flow. For starters, an air flow of 200 °C was added to preheat the fibers. Including all these aspects allows the investigation of the thermal runaway effect as a function of the fiber speed (v_{fiber}) and the microwave power applied (P).
In the model, a constant electrical field strength over the length of the system is implemented as well as the materials properties of a 12k fiber bundle. The model calculates the temperature rise at every z-position along the microwave system length (see Fig. 1). It helps to raise awareness for the thermal runaway for unsuitable parameter combinations. As can be seen in Fig. 2 only a small range in combinations results in the desired fiber temperature of 260 °C. Further steps are to vary the electrical field distribution along the length, the preheated air and to compare the stability ranges of the model with the experiment.

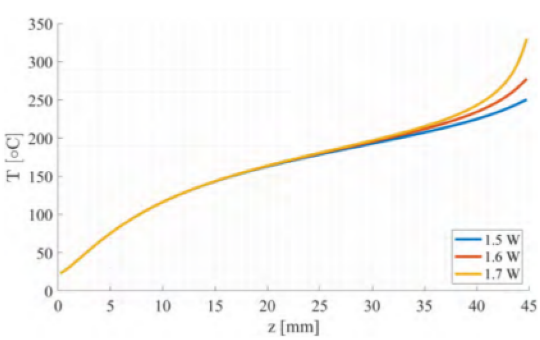

Fig. 1. Temperature distribution over the length z for an air temperature of 200 °C and v_{fiber} of 4 mm/s for different microwave powers.

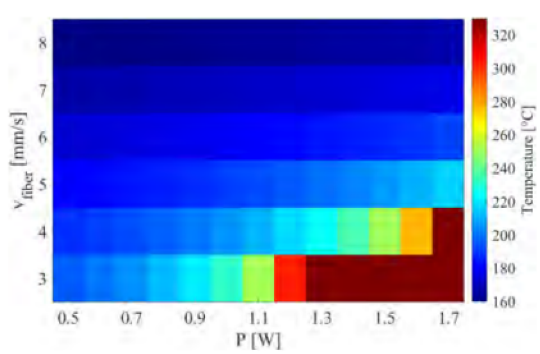

Fig. 2. Maximum temperature due to different combinations of the microwave power P and fiber speed v_{fiber} for an air temperature of 200 °C.

References

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