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MULTIDIMENSIONAL APPROACH TO EVALUATE THE FATIGUE STRENGTH OF GLASS FIBER REINFORCED POLYAMIDE

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ABSTRACT

As one of the world leading automotive suppliers, ZF Friedrichshafen AG put a focus on the use of fiber-reinforced plastics to reduce the overall weight of vehicles. The development of new parts, components and systems requires a holistic approach to ensure the fulfillment of functions with optimum material and energy efficiency while maintaining the economic and environmental requirements. Thus, extensive material and component tests are performed to determine information about the behavior of components under load, which provide the basis for numerical simulations.

Hydrophilic polymers such as Polyamides are challenging the fields of design, qualification and testing. Depending on the atmospheric environment, water can be absorbed or emitted by components which are made of polyamide and in consequence of this a change of geometric dimensions and mechanical properties is a result. Furthermore other parameters such as test frequency, transient sample temperature and mean stresses have to be carefully considered in the experimental procedure and the evaluation. The 2-dimensional S-N-curves are often not constructive and there must be an n-dimensional approach. For this purpose, a new promising approach has been developed in the Central R&D of ZF Friedrichshafen AG, which allows a more precise view of the life time behavior of glass fiber reinforced polyamide in a multidimensional space.

Keywords: S-N curves, glass fiber reinforced polyamide, composites.

INTRODUCTION

Along with the EU directive on the reduction of CO2 emission of a new car in 2020 to 95 g / km, requirements of a higher standard are being placed on the automotive industry. In addition there are issues such as safety, dynamics, comfort and sustainability. To fulfill the EU regulations, solutions for saving total vehicle weight and the associated reduction in the consumption values must be found.

The benefits of fiber reinforced composites are the specific setting of strength and stiffness, wherein the mechanical behavior is determined by the properties of the additive, the matrix and the combination of matrix and additive [1]. The development of new parts, components and systems requires a holistic approach to ensure the fulfillment of functions with optimum material and energy efficiency while maintaining the economic and environmental requirements. Thus, quasi-static and cyclic material and component tests are performed to determine information about the behavior of components under load, which provide the basis for numerical simulations. Failure behavior of fiber-reinforced plastics (FRP) is dependent on many external parameters, such as temperature, humidity, harmful media, etc. If the stress

level is low, the plastic specimen will fail because of fatigue fracture crack propagation, if there is a high stress level, the plastic specimen will fail because of thermal influence. A high test frequency and a high stress level act as multiplier for thermal influence and finally for thermal failure and are leading to an incorrect result due to the heating of the material [3].

RESULTS AND CONCLUSIONS

To determine the dependence of the previous factors influencing the life accurately, further experiments must be carried out with changing variables. This can be achieved with the change of the load ratio, moisture, temperature and the expansion of the frequency range. Within this, more important findings about the fatigue strength behavior can be obtained at the same time.

With a multi-dimensional presentation of the stress variables and the results, the life time behavior of glass fiber reinforced polyamide can be described on clearly both, the outer and the inner influences. Furthermore, a calculation model can be designed to give a better prediction of the life time behavior of glass fiber reinforced plastic components under various boundary conditions.

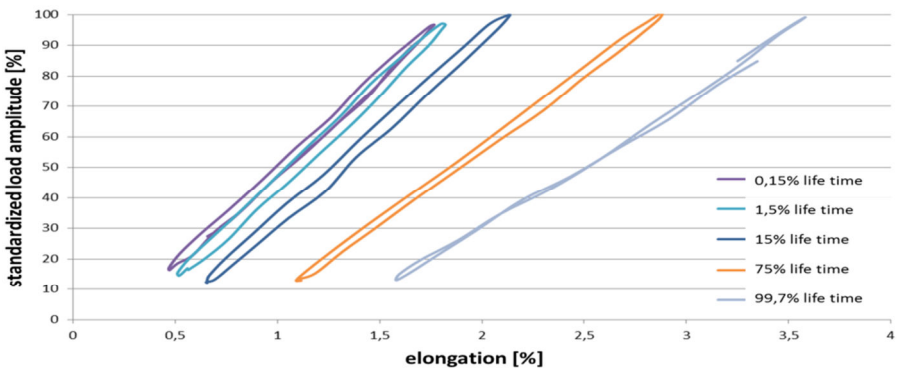

Fig. 1 - Load amplitude - elongation hysteresis curves of fiber-reinforced polyamide under cyclic loading

By the use of multivariate analysis methods, the dependencies of life time load changes N concerning frequency, force amplitude, and the slope of the load amplitude - elongation hysteresis (Figure 1) are described empirically. This method allows a more accurate description of the process and a deeper insight into the "nature" of this process.

Therefore, a standard needs to be found which makes it possible to describe the life time behavior of the material with respect to the outer and inner parameters. Finally, a consensus on a broad scale is required.

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