EXPERIMETAL INVESTIGATIONS TO DETERMINE THE DYNAMICAL BEHAVIORS OF THE 3D PRINTED PLA

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1. Introduction

The 3D technology nowadays is an everyday technology. Today's applications are carried out not only for marketing and rapid prototyping aims. As individual series production or in small series these products are built into machines [1]. The cost and time of the production equipment can be saved by this technology [2]. To apply as a load-bearing element the load capability of the material must be known. To decide this fact, several numerical simulations must be carried out [3]. In case of cyclic external loading conditions dynamic stresses are developing as well. These are typical vehicle industry applications [4]. For these cases the machine parts must be designed for dynamic conditions where the material characteristics – dynamic and fatigue as well – must be known [5].

From everyday experience it is well known that the external loading conditions act on the machine parts and on the complete machine as a function of time to a small or greater extent. A static load or a load which is constant in time can be interpreted as an idealized limit state. In case of vehicles the service conditions (i.e. in case of off-road condition) change in unsystematic way in their value and frequency as well. Based on these facts the loading conditions can be determined by unsystematic functions. The process can be described by stochastic theories, using statistical parameters. The failure process in the part (material) due to the variable loading conditions essentially differs from the failure process in static case. On the surfaces of machine elements (test specimens) especially in the neighborhood of the notches, peak stress areas make the change, in general the external load starting from the crystalloid grid failures may cause micro cracks. From growth of micro cracks during the fatigue process macro cracks could develop.

During the crack propagation process the cross section decreases, in this way the failure can develop in case of finite cycle number. Starting from this fact, the time-dependent parameters must be determined for the description of the fatigue process. In case of the determination of limit fracture conditions (σ_m=C. mean stress, σ_a=C. amplitude, sinusoidal process) as a result a 3D function is realized $\{\sigma_M ;\sigma_A ;N_t\}$.

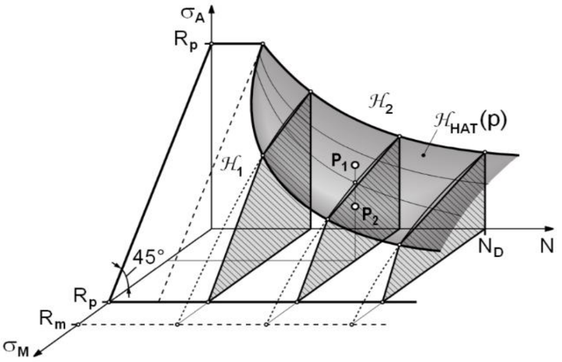

Fig. 1. Limit surface in case of σ_m =C., σ_a =C [6].

In practice the plane-section of the limit condition's area is used for investigation. In case of σ_M =C. the $\{\sigma_A;N\}$ Whöler curve, and in case of N=C. the $\{\sigma_M ;\sigma_A\}$ Haigh diagram is used for investigation [6].

2. Methodology

The fatigue investigation has been realized below the Yield limit as indicated in Fig. 1. To realize this the static material parameters - in our case for PLA material – must be determined. During the fatigue test the alternating load has zero mean value, the push and pull test diagrams must be determined. In case of a material produced by additive manufacturing technology – because of the layer by layer technology – the properties show anisotropy material properties. That means the material shows different behavior in push and pull direction. It causes other difficulties: the material parameters differ according to the production direction [7], [8], [9].

3. Results

Test specimens have been produced in three different possible production directions, as the results are indicated in Fig 2. and Fig. 3.

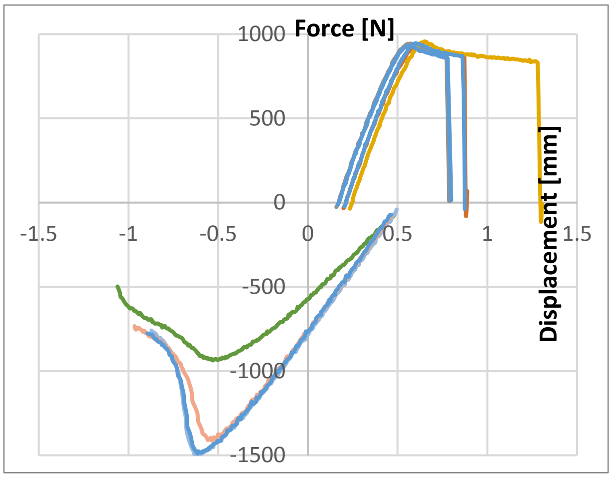

Fig. 2. Force-elongation diagram in “laying” position.

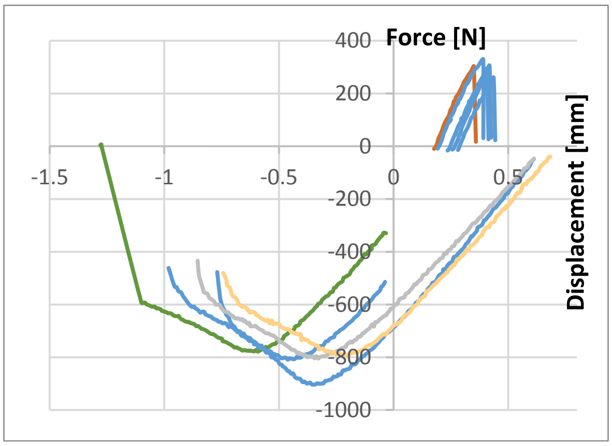

Fig. 3. Force-elongation diagram in “staying” position.

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