N3-O-030101

FABRICATION OF PEEK-CF LAYERED COMPOSITES WITH THE USE OF ULTRASONIC WELDING MACHINE*

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Application of ultrasonic (US) vibrations is one of the most spread methods for welding of thermoplastics. For doing so, high-frequency low-amplitude mechanical vibrations are applied to implement frictional heating of the contacting surfaces, which leads to their local melting and subsequent formation of a permanent joint. Ultrasonic welding allows joining both amorphous and semi-crystalline thermoplastic polymer materials without additional external heating [1, 2].

An advantage of the ultrasonic welding (USW) is a relatively high speed of joint formation process, since the welding proceeds during several thousand oscillatory cycles (from fractions to several seconds). In addition, mass production might be easily automated. Working frequencies of industrial technological US equipment vary from 10 to 75 kHz; however, the 20 +/- 4 kHz band is the most common operating frequency range. In doing so, the amplitude of the working tool vibration displacement ranges from 0.1 to 100 microns.

Recently, various aspects of fabricating laminated thermoplastic based composites with the use of ultrasonic welding equipment have been actively discussed in R&D literature. The relevance of this approach is motivated by a possibility of long-range products fabrication by serial ultrasound-assisted action onto joined layers (parts). It was shown that an efficient approach for US-assisted joining of thermoplastic layers is the use of intermediate (consumable) films (the so-called Energy Director - ED). During the US-vibration exposure, the latter melts and a dense interlayer is formed. In doing so, the lapped plates, as a rule, of the same materials are joined (connected). In addition to films from the same materials, the EDs are fabricated from ones with lower melting points. The ED thickness and porosity are variables; moreover, reinforcing particles and fibers are additionally loaded, etc. Professor Irene Fernandez Villegas from the Delft University of Technology should be refereed as one of the most successful researchers in this area [3].

However, besides joining plates of the same thermoplastic materials, the use of ultrasonic vibrations can be a way of forming layered (laminated) composites, containing layers of reinforcing fabrics. At present, such layered composites based on thermoplastic binders are manufactured mostly by hot pressing of sequentially laid layers of polymers (including films) and fabric [4]. However, the use of prepregs (reinforcing fabric in a binder) can allow the formation of layered composites using ultrasound technologies. This issue is currently just briefly studied in the relevant literature.

The paper is aimed at the study of lap joints formation of thermoplastic materials (in this case, high-strength polyetheretherketone - PEEK) reinforced with carbon fiber fabric with the use of an ultrasonic welding machine.

It was shown that ultrasonic welding of two PEEK plates without the use of the Energy Director did not ensure formation of a high strength lap joint. The introduction of the PEEK–CF prepreg layer between two PEEK plates did not stimulated the formation of a reliable lap joint with high LSS value. The reason was the low weight fraction of the binder in the prepreg (34%).

The formation of a multilayer (laminated) PEEK–CF–PEEK composite might be realized when a prepreg is used as a central layer, while PEEK–film Energy Directors are placed between joined plates. It was shown that a PEEK film with a thickness of 250 μm might be efficiently used. During the tensile test, fracture occurred along the base material, while the lap joint maintained its structural integrity.

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* The study was funded by Russian Science Foundation # 21-19-00741, https://rscf.ru/project/21-19-00741/».