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CREATION OF ENERGY-SAVING TECHNOLOGIES OF FORMING ARTICLES MADE OF POLYMERIC COMPOSITE MATERIALS

Abstract

Polymeric composite materials (PCM) hold the most distinctive position among constructional materials, since they have a number of unique properties – high specific strength, chemical stability, good thermal-insulating properties, providing for wide usage thereof in rocket and space engineering, aviation technology, and other branches of industry. Development of PCM production puts forward demands on increasing efficiency of their processing practice, which involves high energy consumption. Consequently, great importance is given to searching for methods of optimization of PCM production technique. The authors have developed the concept of obtaining energy-saving technologies for PCM meant for constructional needs due to optimization of the modes of impregnation and forming of articles, which determine their physical-and-mechanical characteristics to a large extent. Quality of articles made of PCM depends on three complex parameters: -value of residual stress condition, connected with shrinkage of the binder, and temperature deformation of the material; -amount of gaseous inclusions depending on the content of volatile products in the binder; - degree of cure of polymeric binder. It was determined that for obtaining of high-quality PCM article the production process of forming should be carried out so that to ensure first two parameters' values being as low as practicable, and the last one maximally approaching 100Shrinking deformations occur at the stage of gel formation, and depend on the rate of temperature change in time. Volatile products of polycondensation start to form after gel point. Rate of their formation proves intensity of the reaction, which is accompanied by changes in viscous properties of polymeric matrix. In this case, a situation arises, when pressure of volatile products dissolved in the curing polymer is less than external pressure, which leads to pore formation. Amount of pores depend on external pressure determined by forces of forming, and surface tension forces of the binder. Optimal temperatures for various classes of binders and adhesives, corresponding to maximum output of volatile products, were determined. Temperature and time regimes for binders and adhesives were specified, which regimes comply with conditions of laminar flow, and it, in turn, provides for uniform impregnation of the fillers. Temperature and time regimes define the temperature, at which the binder has minimum viscosity in definite time. The authors used electro-physical method for determination of the degree of cure, which reflects dynamics of the curing process according to temperature and holding time with utmost reliability. Usage of the above method

allowed to monitor the state of material in the process of its structuring, and to reveal the moment of achieving maximum viscosity, beginning of gel formation, transition of material from visco-elastic state to vitreous state, and completion of structuring process. The represented method of choice of regime and curing control, based on the investigation of gas release kinetics, in combination with active dielectric control of gel formation kinetics, gives an opportunity to find proper temperature and time regime of fillers' impregnation and heat treatment thereof, ensuring reduction of the heat treatment cycle with due observance of requirements to quality of material, and to obtain the material with minimum porosity. The data obtained regarding the degree of cure, depending on temperature and holding time, with the use of electro-physical method, describe the curing dynamics with utmost reliability, and such data can be adopted for constructing optimized process, with achievement of maximum degree of cure. The given method can be taken as a basis for solving tasks on choosing the method of continuous non-destructive testing of the process of PCM articles' production. Developed concept was tested in conditions of experimental and industrial production of Ukrainian Research Institute of Manufacturing Engineering OJSC (UkrNIITM OJSC), and it allowed to reduce energy consumption during PCM curing, to decrease heat treatment cycle 1,5-2 times, and to cut down expenses for servicing of ovens (autoclaves).