MATERIAL PROCESSING TECHNOLOGIES

Lecturer PhD. Adina TĂTAR, „Constantin Brâncuşi" University of Târgu-Jiu
Lecturer PhD. Nicoleta MIHUŢ, „Constantin Brâncuşi" University of Târgu-Jiu
Georgi VELEV, Technical University of Gabrovo, Bulgaria

ABSTRACT*: The development of electrophysical processing methods and their use in production marked a major advance in the technology of processing materials, inasmuch as electricity became a working agent instead of an auxiliary means of mechanical processing. Environmental protection ranks high in public opinion, and has become an important part of market economy. Especially industrial production is linked with risks to the environment. Despite various advantages, these processes may generate solid, liquid or gaseous by-products presenting hazards for workers or the environment. The sort and quantity of the hazardous substances, and suitable measuring methods are discussed. Furthermore, strategies to reduce emissions and to protect environment from possible impacts are explained. The increasing use of such methods in industry is due to their high productivity and to the feasibility of performing production operations that are not possible with mechanical methods. The work presents the results of mathematical modeling of polymer-modified carbon materials microwave heating, checked the adequacy of the model and practical recommendations for the industrial manufacture of products by SPE using short microwave heating for mechanical engineering.*

Key words: electrophysical, processing, polymeric materials, ultrasonic, mechanical methods

1. ELECTROPHYSICAL PROCESSING METHODS

In modern engineering, electrophysical processing methods are used to process critical parts. These methods complement and sometimes replace conventional cutting methods.

Holes, slots and shaped slots of ultra-small sizes, as well as connecting channels located in hard-to-reach places, often cannot be machined.

Electrophysical and electrochemical methods are used to obtain surfaces of wear-resistant, corrosion-resistant, heat-resistant, high-precision and low roughness.

The increasing use of such methods in industry is due to their high productivity and to the feasibility of performing production operations that are not possible with mechanical meth ods.

The great variety of electrophysical and electrochemical processing methods may be. arbitrarily divided into electrophysical (electroerosive, electromechanical, and beam), electroc hemical, and the combination methodsare removed from the surface of a material by means of an electric discharge or pulse.

For a given voltage (or distance) between electrodes immersed in a liquiddielectric, the dielectric will break down as the electrodes are drawn closer (or the voltage is increased); as a result, an electric discharge occurs, creating a high-temperature plasma in its path.

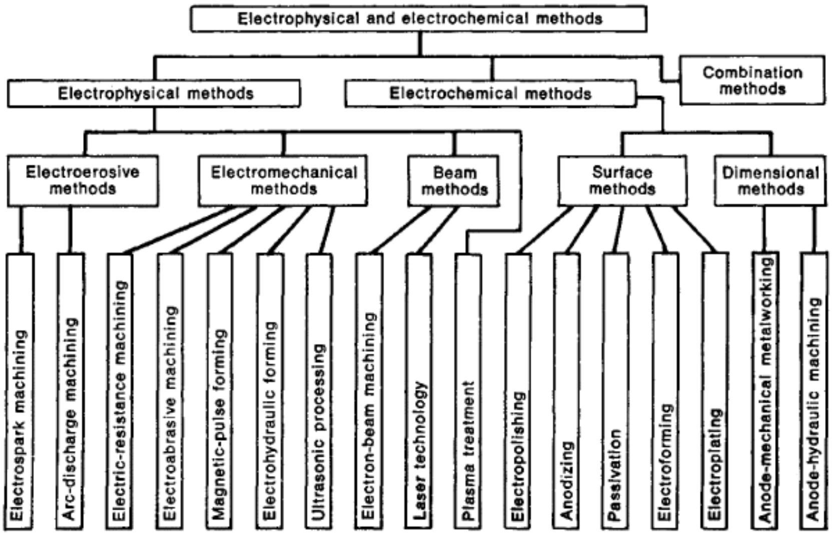

Figure 1. Classification of the principal methods of electrophysical processing

2. POLYMER COMPOSITE MATERIALS (PCMS)

Further progress in the field of plastics processing associated with a sharp increase in the productivity of the processing equipment, reducing energy intensity of industrial production process and improving product quality.

The solution of these problems is impossible without the use of new advanced processing techniques, which include various types of polymer pressure processing in the solid aggregate phase (bulk and sheet forming, and the solid-phase hydrostatic extrusion, other methods of intense plastic deformation), in conjunction with the imposition of electro physical impact energy fields on the polymer.

At the present stage of development of science and technology, polymer composite materials (PCMs) are a fundamental element in the implementation of innovative solutions involving the creation of new designs and devices, as well as appropriate technologies.

These PCMs are widely used in the aerospace industry, aircraft, sports, biology, chemistry, medicine, electric power industry, microelectronics, machine building, military, and other industries. The study of the physicochemical aspects concerning the surface properties of the constituent components of PCMs is the foundation of the subsequent wide practical use of the results of such research in the form of creating innovative technologies.

In particular, improving the interfacial interaction of the constituent components of the PCMs is a key factor for improving the reliability of the cured filled composites.

Due to the problem of solid phase scientific basis creating and polymer processing technology, development, of multicomponent polymeric materials formulation that meet the requirements of the new technology of thermoplastics methods by intense plastic deformation (IPD), the REC TSTU-ISMAN, "Solid-Phase Technology," is developing scientific field that is associated with the improvement techniques of difficult polymers solid-phase processing technology, thermally unstable and ultra-high molecular weight polymer overlay on the material, and snap of electro physical energy fields influence of different nature.

Therefore, research in the field of design and projecting on the basis of the structural-parametric method of both existing PCMs and new PCMs with improved surface properties is the current direction of polymer material science and polymer technology.

A promising area of research in polymer technology is the modification of the surface of reinforcing fiber filler (FF) and liquid PB to increase their contact properties in the composite.

The optimal modification of the above components leads to the improvement of the physicomechanical and operational properties of the composites, moreover, both traditional PCMs and nanomodified (NM) PCMs.

For example, carbon fiber composite materials with improved performance properties are a typical example of the implementation of the modification of the surface of carbon fiber and PB. At the same time, ultradisperse carbon nanoparticles are uniformly distributed in the volume of a liquid PB, while macrofiber carbon plastics, in turn, are surrounded by this combined PB.

Improving the performance properties of NM PCMs is also directly related to the improvement of the interfacial interaction of their constituent components.

Depending on the composition and properties of the components, including the magnitude of the surface energy, as well as the features of the composite manufacturing technology, it is possible to obtain NM PCMs of various functional purposes.

At the same time, in addition to analyzing promising areas for the development of NM PCM technologies, economic factors for the implementation of such technologies are important, which predetermine the feasibility of industrial implementation of completed projects.

It is well known that the main difficulties in obtaining NM PCMs are due to the need for uniform distribution of nanoparticles in a liquid oligomer (polymer) to ensure maximum contact surface between the liquid polymer system and nanoparticles incorporated into it, especially based on carbon. Subsequent polymerization or polycondensation of monomers and oligomers leads to the formation of grafted polymers that are chemically bound to the substrate, for example, in the form of a nonmetallic or metallic surface.

In the case of reactoplastic polymers, there is often a correlation between the adhesion strength and the cohesion of the film coating material.

One of the effective ways to increase the adhesion strength of a joint while simultaneously increasing the productivity of the molding process is the physical modification method, which consists in using a contact ultrasonic field. We should also mention another class of innovative PCMs, namely, intellectual (smart) PCMs, including NM PCMs.

PCM intellectualization is achieved by modifying polymer composites with components that contribute to the transformation of such materials into materials that self-diagnose and adapt to external temperature-force effects.

This direction of research is extremely important and, apparently, will determine the future development of innovative polymer technology.

Experimental studies of modified polymer was carried out on an experimental installation with a cell of high pressure on a universal testing machine UTS 101-5 at V = const at different extrusion speeds in the range of V = 20 ... 100 mm / min.

SPE at the optimum temperature of processing significantly reduces the required molding pressure, improving the performance of the extrudates.

The process of incubation takes a long preparation time (about 30 min). The use of microwave heating can reduce heating time of blank from tens of minutes to tens of seconds.

To intensify the process of solid-phase processing of polymer-modified carbon materials has been proposed a method of thermoplastics molding using microwave heating

Analysis of experimental data on the kinetics of microwave heating shows that the rate of heating of CNT powder (5 ... 8 °C / s) significantly exceeds the rate of the initial polymer heating (0,1 ... 0,4 °C / s).

The bulk microwave processing of polymer-carbon materials and products allows to use high energy, electric and heat conducting properties of carbon to form a polymer matrix with improved properties. Since carbon is a good conductor its heat speed rate is significantly higher than the polymer material, there is a more intense heating of the carbon particles.

This leads to local heating of the boundary surface of the polymer and the carbon material up to the melting of the polymer. The bulk of the polymer-modified carbon material does not have time to warm up and remains in a solid structured phase.

Microwave heating allows keeping all advantages of solid-phase processing (orientation of the macromolecules due to shear deformation with a corresponding increase in the strength characteristics of the finished product), use the local area around the molten carbon particles to increase the deformability of blanks, determined by the structural mobility of the polymer matrix. As a result, the SPE decrease the required molding pressure Pf at 10 ... 20%.

In addition, the expansion by heating of locally melted polymer film and the carbon particles, the limited by solid basic part of the polymer matrix, resulting in a significant increase in internal pressure and, consequently, increase the area of the boundary surface of the polymer matrix with particles of carbon. This effect further affected on strength characteristics increasing of the finished products produced by SPE.

One of the methods of material strength characteristics improving is to reduce the residual stress of extrudates σost. It is established that the use of prior microwave heating can reduce σost in 2 - 4 times. At the same time an interesting pattern was marked: for the modified materials in the field of ultrasmall additives (0.05 ... 0.3 weight parts. CNT) is characterized by too low level of σost at the time of microwave heating from 20 to 60 from (0.2 ... 0.6 MPa) and in the range of 0 ... 60 ... 20 and 100 σost more than 1 MPa. In the diagram analysis of the isometric heating was a slight increase in temperature of materials thermal resistance that have passed the SPE using microwave heating (TTP increases by 5 ... 30 K).

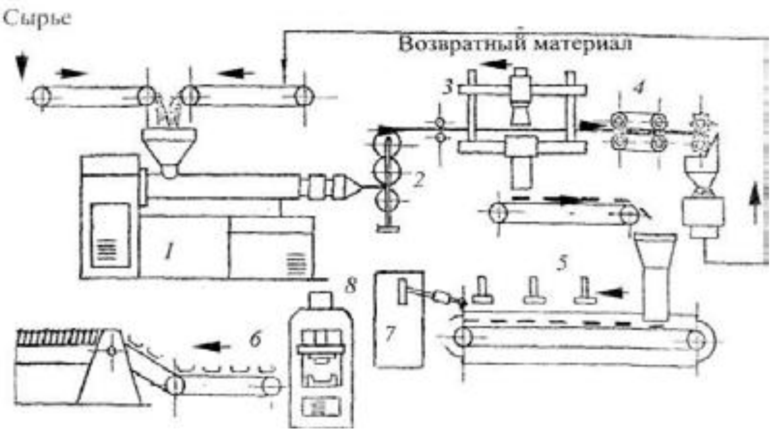

Figure 2 Scheme of obtaining products process of thermoplastics by sheet stamping, using short microwave heating:1 - extruder, 2 - feed rolls 3 - punching device, 4 – grinder, 5 - microwave generator, 6 - transporter, 7 – manipulator, 8 - the press.

Developing the intensification of the process method of solid phase forming (for example, SPE) nanomodified polymeric materials based on physical and physico-mechanical studies of the material structure and properties that have passed the SPE, it was found that the use of microwave heating:

- Reduces the required molding pressure Pf ≈ 10-20%;
- Increasing the strength in uniaxial tension σr by 20-50%;
- Increases strength in shearing stress σsr ≈ 10-30%;
- Reduced level of residual stresses σos in 2-4 times;
- increases heat resistance Ttp of materials by 5-30 K, the melting temperature Tpl – at 5-40 K;
- microwave heating use is structuring carbon black (soot). The efficiency of using it as a filler of polymer materials rises to the level of CNM.

3. CONCLUSIONS

In considering the mechanism of ultrasonic action on the polymer in a solid phase treatment should be allocated three factors: mechanical, thermal and physico-chemical whose action is closely related. Mechanical factor due to the varying acoustic pressure because of alternating compression zones and rarefaction of the material and is manifested in the vibrational "healing" of defects on macromolecular "micro" and super molecular "meso-levels" polymeric matrix. Mechanical factor of ultrasound exposure leads to molecular fragmentation of its crystalline modifications as a low melting and high melting, reduction of medium-weight molecular weight and mass transfer processes of macromolecules fragments from one modification to another.

The heat factor caused by absorbed transformation of mechanical energy of ultrasonic waves into heat. Raising the temperature of the material leads to an increase in the rate of relaxation processes in the structure of polymeric matrix and polymer composite in general due to the acceleration of diffusion processes in the polymer system.

Supplying of additional ultrasonic energy to the polymer in the solid phase processing reduces the required molding pressure in the product forming, reduces the stages number of the process, reduces power consumption of all process per unit of output.

Physico-chemical factor is manifested in the change of physico-chemical, molecular relaxation and molecular-topological characteristics of the processes and structure of amorphous-crystalline polymer in the solid phase forming process combined with ultrasound exposure. Ultrasound is a catalyst for these processes and quantitative changes in economic structure. Ultrasonic treatment leads to the formation of free radicals as a result of mechano-chemical reactions of macromolecular fragments destructive chains and supramolecular structures, the formation of embryos, or active sites of plasticity, the so-called "Shear effect", activation of redox processes by increasing the mobility of the structure and associated with these processes increasing the degree of crystallinity, the healing of the defective areas, increasing monolith structure and growth of physical-mechanical properties of amorphous-crystalline polymer.

BIBLIOGRAPHY:

[1]Abramov, O.V. - *Ultrasonic processing of materials* / O.V. Abramov, I.G. Horbenko, Sh. Shvegla, ed. O.V. Abramov. - M: Mechanical Engineering, Bratislava: Alpha, 1984. - 280p.

[2]Aleksandr E. Kolosov , s.a, - *Use of Physicochemical Modification Methods for Producing Traditional and Nanomodified Polymeric Composites with Improved Operational Properties* 2 1 National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, 2019

[3]Baronin G.S, D.O. Zavrazhin, mag. D.E. Kobzev, - *He intensification of solid-phase forming process of polymers and composites with electrophysical effects of microwave and ultrasonic fields,* Scientific proceedings ix international congress "machines, technologies, materials" 2012

[4]Cherepanov, Iu. P., and B. I. Sametskii -E*lektrofizicheskie i elektrokhimicheskie melody Razmernoi obrabotki materialov.* Moscow, 1972

[5]Kalganova S.G. - *Electrotechnology of nonthermal modification of polymeric materials in a microwave electromagnetic field*. Dissertation theses for the degree of Doctor of Science // Saratov, 2009.

[6] Sanditov, D.S. *The model of free volume fluctuation and structure of amorphous polymers and glasses* / D.S. Sanditov, Sh.B.Tsydypov, A.B. Bainova // ultrasound and thermodynamic properties of matter. - Kursk: Izd-vo KGU, 2003. - Vol. 29. - p. 123-132.

[7]Ganiev, M.M. *Improving performance of polymer composite materials with ultrasonictreatment.* Kazan: Kazan Univ. State. Technical. Press, 2007. - 83.

[8]Vishnitskii, A. L., I. Z. Iasnogorodskii, and I. P. Grigorchuk. *Elektrokhimicheskaia i el ektromekhanicheskaia obrabotka metallov*. Leningrad, 1971.

[9] Voronezhtsev, Yu.I. *Electric and magnetic fields in the technology of polymer composites* / Yu.I.Voronezhtsev, Scientific proceedings ix international congress "machines, technologies, materials" 2012 print issn 1310-3946 year xx, volume 1, p.p. 15-18 (2012) 17