Considering the extreme importance of polymer composites in meeting the demands of industry and supplying consumer goods, the journal Plasticheskie Massy will be publishing three 2002 reviews on these problems. The reviews are based on papers presented at conferences held in the Ukraine and in Latvia.

This issue of the journal reflects work presented at the 12th International Conference on the Mechanics of Composite Materials which was held on 9–13 June 2002 in Riga (Latvia). These regular conferences have been conducted since 1965 at 2–3 year intervals and are organised by the Institute of Polymer Mechanics of the Latvian University.

At the 12th Conference, 195 papers and reports were presented from 28 countries, including nine republics of the former USSR. The reader will be able to find the full text of some of the papers in the journal Mekhanika Kompozitsionnykh Materialov, which is published in English and Russian.

The main themes of the conference were as follows:
- structure and properties of composites;
- long-term deformation properties and strength;
- strength, failure, damage, and fatigue;
- structure of composites;
- non-destructive testing;
- mechanical aspects of technology;
- numerical methods.

Furthermore, two symposia were held:
- Composites in Civil Engineering and Infrastructure.
- Mechanics of Composites.

This review gives data from papers presented by almost half the participants. A review of the remaining publications will appear in the 2002, No. 10 issue of Plasticheskie Massy.

Among the British studies of composites that were presented at the conference, of note were the papers from the universities of Bristol and Plymouth by Professor Adamson. They were devoted to the study of the possibilities of establishing a relationship between the long-term strength of fibre-reinforced polymers and the low-temperature transitions observed in composites. Experimental methods had been developed for accurate determination of attenuation in degrading glass and carbon fibre reinforced plastics. The possibility was shown of controlling the nature of change in epoxy binders and thermoplastic polyetheretherketone matrices, and of obtaining valuable information on the state of the binder in the presence of adsorbed water causing a plasticising effect during prolonged ageing under load.

In the second paper, an examination had been made of methods for the recycling of polymer composites, including thermal breakdown of the polymer phase and the production of new types of filler from the recycled material.

Papers by Italian specialists presented work on the production of reinforced composites and the influence of external factors on the reinforcing effect, and an experimental investigation of the effect of temperature and moisture on the mechanical properties of carbon fibre reinforced plastics. Experimental results obtained on carbon fibre reinforced plastics showed that external natural effects resulted in a sharp deterioration in tensile strength. These problems could be overcome by modifying the matrix polymers. In two other studies presented by the same teams, an analysis had been made of the failure and deformation of concretes reinforced with glass fibre...
plastic cylinders and sheets.

Work by the Venetian University of Architecture Institute set out the results of mechanical and non-destructive tests making possible the effective strengthening, with the aid of composite materials, of historical arched bridges in Venice that were built in 1552. Materials based on epoxy resins and Kevlar fibre had been used.

The Institute of Macromolecular Chemistry of the Ukrainian Academy of Sciences presented papers on composite materials whose binders were interpenetrating molecular networks of three-dimensional polyurethane and linear polystyrene. The considerable effect of a compatibilising addition of ethylene glycol monomethacrylic ether was demonstrated. It was shown that the degree of microphase lamination of the binder was due to the conditions of formation of the interpenetrating network.

The Martin Luther University in Germany presented work on non-classical criteria of the limiting state and its application to polymers. A new criterion of static failure was proposed for isotropic polymers with different tensile and compression strengths.

Specialists of Kazan’ State Technical University presented work on modelling the properties of materials of different viscosity. Epoxy resins and triglycidyl esters (TGEs) of phosphoric acid had been used as epoxy oligomers and cured with amines. It was shown that the gradient of mechanical characteristics was caused by irregular distribution of the modifier through the thickness of the specimen owing to the thermodynamic incompatibility of the epoxy oligomers and TGEs.

In work by the University of Polymer Mechanics, an investigation was made of the effect of water, elevated temperatures, and fatigue on the mechanical properties of carbon fibre reinforced plastics with epoxy binders for the production of flexible rods. For comparison of the properties of composites, use had been made of a three-point bending and loading scheme with a frequency of 5 Hz. A fall in the properties of these composites under mechanical stresses and the action of external media was demonstrated. Furthermore, work on investigating the structural changes in polyester resins under the action of moisture and mechanical loads was presented. Norpol-440 had been used as the binder. It was shown that the most significant changes occurred at a temperature of 60–80°C. Temperature effects led to a 50% increase in the moisture content. All structural changes, and also shrinkage caused by desorption of moisture, ended when the temperature reached 80–85°C. With further increase in temperature, there were no changes.

The Perm’ School of Composites was well represented at the Conference. The paper by the Perm’ Technical University presented a mathematical model for calculating inelastic strains and the accumulation of damage in unidirectional reinforced fibres and composites under conditions of longitudinal shear and combined transversal and longitudinal loading. Specialists of Perm’ State Technical University had studied the long-term strength of glass fibre reinforced plastic pipes at pressures up to 6 MPa and temperatures up to 120°C, and under chemical action and wear. The composite pipes had a polymeric functional inner layer. The bearing frame of the pipe was manufactured from glass fibre reinforced plastic, and therefore the long-term strength of a two-layer composite pipe had been investigated.

Prolonged tests conducted over a period of 5 years at a pressure of 6 atm at 20 and 70°C had demonstrated the promising properties of the pipe and the possibility of predicting its properties.

The next work presented by the Perm’ State Technical University was an investigation of the influence of structure on the stresses and strains in stochastically reinforced composites. An examination had been made of unidirectionally reinforced composites, unloaded porous structures and structures filled with spherical or elliptical inclusions. The characteristics of the stress and strain fields had been found numerically. The variances of the stress fields had been calculated for conditions of elongation, shear, and hydrostatic compression.

Colleagues of the Perm’ State Technical University had carried out work on analysing schemes of reinforced carbon–carbon discs. It was shown that, for carbon composites reinforced in three orthogonal directions, the calculation methods proposed gave good accuracy.

At the Institute of General and Inorganic Chemistry and the Institute of Metal–Polymer Systems of the Belarus’ Academy of Sciences (V. I. Dubkova and O. R. Yurkevich), work had been carried out on optimising technology for applying protective polyolefin film to concrete, wood, and metal surfaces. Materials had been chosen for the horizontal and vertical fixing of films.

In work by the Laboratory of Reinforced Plastics of the Institute of Chemical Physics of the Russian Academy of Sciences, a study had been made of the impact properties of glass fibre reinforced plastics based on blends of polysulphone and epoxy. It was shown that the addition of polysulphone in a quantity of 5–10% had a favourable effect on the shear strength and impact strength.

In work by the Swedish Institute of Composites, an analysis had been made of the mechanical behaviour of untwisted fibres and their influence on the properties of composites. A model had been created that described the behaviour of these materials.

In work by the Institute of Non-metallic Materials of the Siberian Division of the Russian Academy of Sciences (in Yakutsk), two models had been presented and tested for predicting the kinetics of change in the short-term strength of thermoplastics under conditions of ageing in a cold climate. The satisfactory correlation between strength values determined over a period of 3 years and data
within an 11 year period was shown. In following work, this team had studied the strength and mechanism of degradation in thermosetting polymers during ageing. Three degradation mechanisms had been investigated:

- the formation of a layer of surface damage of 100 µm thickness;
- rupture of the bonds between the fibre and matrix in dispersed reinforced plastics;
- change in the size and structure of the pores in cellular plastics.

Glass-filled polyamides had been used for the investigation.

In work by the Technological Institute in Kelce (Poland), an investigation had been made of processes of failure under conditions of fatigue loading of orthotropic composites by acoustic emission. It was shown that, using the energy parameters of acoustic emission, it was possible to identify the mechanisms of fatigue failure in composite materials.

In the paper by representatives of the Kelce Polytechnic and the Riga Technical University it was stressed that the important problems of determining the static strength and fatigue life of composite materials, which failed more rapidly than metal, could be solved by non-destructive methods of acoustic emission.

Work by the Ukrainian Chemico-Technological University (in Dnepropetrovsk) had been devoted to an investigation of the influence of the conditions of formation of the adhesive contact on the mechanical properties of basalt plastics. The investigation had been carried out on basalt plastics based on matrices of high-density polyethylene and a copolymer of trisoxane with trioxolane (TCT). As a result of the work, the optimum conditions were found for obtaining and treating basalt plastics for the production of articles with high mechanical characteristics.

Work by the Kiev National University, named after Taras Shevchenko, had been devoted to modification of the structure and properties of polyvinyl alcohol by polymers of a different chemical nature. The modification of polyvinyl alcohol with polyvinyl pyrrolidone, polyacrylamide, and hydrated polyacrylamide had been studied. The stress–strain dependence for crack-preventing elastomer coatings on concrete substrates had been studied in work by the companies 'Corpem' and 'Polymate' (Israel). It had been shown experimentally that the resistance to crack formation in coatings was determined by their limiting deformability, adhesion to concrete, elastic modulus, and strength. A mathematical model of a concrete–coating composite for the stage of loading up to crack formation was proposed.

In work by the Missouri Roll University (USA) (A. Belarby) an investigation had been made of the use of reinforced polymers instead of metal reinforcement in concrete. As a result, a new scheme for the reinforcement of concretes had been developed.

Specialists of the Donetsk Institute of Physics and Technology of the Ukrainian Academy of Sciences had studied the use of thermal shrinkage in the insulation, packaging, and fastening of materials. A study had been made of composites based on crosslinked or polycrystalline polymers filled with thermally foamed graphite. For thermosetting polymers, TEK systems were used as binders, making it possible to obtain products with a volume of over 50%. Physical models explaining the observed effect were proposed. The situation with the arrest of a crack developed in strip weakened by an internal or external applied defect had been examined in work by the University of Roorkee (India). Relationships were given that determined the size of the plastic zones preventing crack propagation. In other work from India, carried out at the Maharashtra Technological Institute, an examination had been made of the use of natural fibres for improving the properties of polymer composites. Biological structures consisting of cellulose, hemicellulose, and lignin had been used as natural fibres. An examination had been made of the use of sisal, abaca, coconut, and jute for the production of composite materials. The possibility of the effective use of natural fibres for the production of composites with specific properties was demonstrated. The need to protect natural fibres from the action of fungi was emphasised. A good result with natural fibres was given by their preliminary treatment with acrylic acid, which improved the mechanical properties of the composites and reduced their tendency to absorb water.

The A. F. Ioffe Physicotechnical Institute of the Russian Academy of Sciences (in St Petersburg) presented two papers at the Conference, devoted to an assessment of the molecular mobility in the interphase layers of amorphous crystallising polymers (Yu. M. Boiko and V. A. Marikhin). A study had been made of amorphous polyethylene terephthalate (PET), polystyrene, and polyphenyl oxide. It was shown that the molecular mobility in the interphase layers of such amorphous crystallising polymers as PET was suppressed considerably by comparison with amorphous non-crystallising polymers, for example polystyrene. The depths of diffusional penetration and motion of a chain segment in the melt had been studied on polystyrene and polyphenyl oxide systems.

In studies by the Dnepropetrovsk Agrarian University (the Ukraine), the results of investigating the thermophysical and physicomechanical properties of composites based on complex aromatic aramide fibres and polycarbonate were given.

Composites had been prepared by original technology using a rotating electromagnetic field, which made it possible to distribute fibrous filler on the matrix as evenly as possible. Aramide plastics containing 5–35 wt.% Vniivlon fibre had been moulded into blocks by processing.

Colleagues of the Lulea University (Sweden) presented five reports. In the first, an analysis had been made of the
possibility of predicting failure in short-fibre composites. The main materials studied had been polymer composites reinforced with short fibre or with mats, i.e. materials in the form of sheet or bulky moulding compositions (SMS, BMC) to be used in the motor industry. An analysis had been made of the processes of plastic flow or failure in the zone in front of a growing crack. The possibility of theoretical description of the stress–strain curves obtained experimentally had been established.

In the second report, presented jointly with the Latvian University, an analysis had been made of the question of the ideal impregnation of fibre networks. Processes of transfer of the binder during moulding and vacuum bag forming had been analysed. The effect of two types of porosity of the order of 10 μm and 1 mm was emphasised. Processes of the permeability of fibre systems having large channels, promoting penetration of the binder, and blocking points had been analysed. It was shown that of greatest value in the creation of a model of permeability were methods for ensuring the optimum channel size.

In the third report, colleagues of the Lulea Technological University (Sweden) had analysed the process of distribution of the strength of linen fibres obtained by separating fragments from base fibre. It was shown that, although linen fibres were compatible with glass fibres in terms of mechanical properties, during production, linen fibres accumulated damage, and their properties deteriorated markedly. Furthermore, of great importance was the adhesion of these fibres in matrices. To solve the problems arising, it was recommended that the method of formation of a composite fragment with a single fibre be used. The distribution of strength of linen fibres had been studied by this method.

The fourth report by colleagues of the Lulea Technological University (Sweden) was devoted to the influence of the internal structure on the mechanical properties of composites with untwisted fibres. In the paper it was noted that, in recent years, the use of composites with untwisted fibres had broadened considerably. The reason for this was the high quality level of the composites which could be produced more simply and cheaply using this group of fibres rather than prepregs, while the mechanical properties of rigidity and strength were normally better than in the case of interwoven fibres.

The results of the investigation showed the possibility of using fibres of suitable size and density to obtain the optimum mechanical properties of composites with these fibres.

In the fifth report, the absorption of water and the failure of glass fibre reinforced plastic laminates based on vinyl ester binder with pronounced internal layers was discussed. Typical variants of the application of such structures were boats, yachts, and parts of bridges. Composites with high flow were needed for the vacuum compaction of these layers. The degradation rate under the action of water differed sharply for different types of internal layer. It was shown that glass fibre reinforced structures with three-dimensional reinforcement had much greater stability compared with materials of other structures during exposure in water for 3000 h at a temperature of 90°C.

In the paper presented by the Kaunas Technological University an analysis had been made of the influence of different factors on formation of the rigidity and strength of multilayer composites. It was shown that the most efficient structure was a symmetrical multilayer structural element with a minimum number of layers of different thickness.

Colleagues of the D. I. Mendeleev Chemico-Technological University presented a paper on epoxy–amine composites with promising properties. A study had been made of the processes of curing of epoxy–amine structures by methods of viscometry and differential scanning calorimetry. Besides this, processes of the emergence of internal stress during curing had been studied. It was shown that the level of internal stress could be lowered by introducing thermoplastic modifiers.

The Poltava State Technical University of the Ukraine presented two reports on calculation of the behaviour of composite bars under conditions of compression and bending. Theoretical values of the parameters of strain were compared with experimental data. It was shown that classical approaches could not be used in view of the impossibility of taking into account the homogeneity of the material. To solve these problems, it was recommended that an iteration model be used.

Colleagues of Paderborn University (Germany) and Chongking University (China) presented work on the process of failure of composite laminates during monotonic elongation and fatigue loading under conditions of elongation, and on the accumulation of damage in the form of cracking of the matrix and local delamination preceding catastrophic failure. The influence of related damage on loss of rigidity of the system had been analysed. The possibility of using three models of a laminate had been assessed. The levels of microstress and microstrain in the region of cracking and delamination had been evaluated. It was shown that a three-layer model taking into account short-range interactions could be used for analysis of the loss of rigidity.

Colleagues of Dresden Technical University (Germany) presented two papers. The first work had studied promising calculation methods for the textile reinforcement of hybrid composites with an applied notch. The practical use of the proposed relations was demonstrated for the case of real constructions. The second work had been on the design of tests of fibre-reinforced conical rotors. A mathematical model had been developed that described the behaviour of the rotor under the action of forces during centrifuging.
The conditions of thermal loads had been analysed. Tests of conical rotors had been carried out using a special system of telemetry on special test cells.

Colleagues of the University of Science and Technology in Okhank (Korea) had analysed the structures of antennae from composite laminates of different structural rigidity. The construction and technology for the production of antenna structures had been studied. It was shown that electrical measurements gave good agreement with the results of mechanical tests. As a result, it was possible to achieve good bending characteristics.

Riga Technical University presented work on the effect of water on the physicomechanical properties of a composite containing recycled polyethylene and linen fibre production waste. An investigation had been made of the absorption of water on two types of recycled polyethylene produced from waste of household films and industrial waste. In both cases, diphenylmethane isocyanate was the second agent. Modification of systems with this product indicated an interesting practical result connected with increase in the breaking elongation in the system for composites with a high content of linen waste (40–50 wt.%) the breaking elongation increased by a factor of 2–3.

The problem of predicting, from data of short-term tests, the time dependence of the mechanical behaviour of radiation-modified polymers was set out in work by the Institute of Mechanical Polymers (R. D. Maksimov). The work had been carried out with promising Dauleks materials which, even without radiation crosslinking, gave good heat resistance results. The temperature dependence of the shear factor had been determined using the Arrhenius equation. Experimental creep curves had been plotted, and these could be described in accordance with creep theory. Data on long-term stress relaxation could be determined on the basis of short-term tests with increase in temperature, using principles of temperature–time reduction. The results obtained confirmed the possibility of using this material for the creation of heat shrinkage articles.

As can be seen from the review, in countries of the former Soviet Union and abroad, intense research is going on, ensuring new directions in the use of composites.

In the second part we will complete the review of the papers of the 12th Conference and acquaint readers with the state of the art of studies at the Institute of Polymer Mechanics of the Latvian University.

(No date given)