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THE CONFORMITY ASSESSMENT OF METAMATERIALS QUALITY MANAGEMENT

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ABSTRACT

The issues of quality management and ensuring compliance with the requirements of the certification body conducting conformity assessment and quality control of metamaterials. The variety of metamaterials determines a large number of technologies of their production. For many metamaterials it is necessary to carry out not only tests, but also the control of processes providing technology check and modeling of technological operations. When checking the actual execution of the technological process, the possibility of traceability of products from metamaterials throughout the technological cycle is estimated. Cross-checked against the recording required data such as the card heats of registration of the passport. Technological operations are modeled and their metrological support is evaluated. In the formed database of technological parameters of production identification and traceability of suppliers of melting and casting units, furnaces for homogenization, the deforming equipment, furnaces for heat treatment in relation to production of each concrete metamaterial shall be provided. For example, the execution of works on assessment of technologies for the manufacturing of composites with the certification of their production shows areas where necessarily require the particular attention of experts. For a representative sample, including 53 parties submitted the map middle and map scale. On the example of the coincidence of activities of a legal entity and a certification body accredited and operating on the basis of the University, the conditions of compliance with the law of conformity assessment of metamaterials, as well as products and products from them are shown. It is shown that the data and the results of its evaluation of the quality of the metamaterial and stability of the technological process should be analysed and checked by the members of the Commission with regard to mandatory corporate culture employees. Recommendations for procedural support and actions to confirm compliance are given.

Metamaterials have, among other things, special electromagnetic properties [1–3], that can be confirmed for the purposes of further application through certification. ISO / IEC 17067: 2013 describes the basic provisions of product certification and provides guidance for their correct understanding and use [4]. Product certification is the procedure for verifying the conformity of products to the requirements specified by an impartial third party [5]. Product certification is carried out by certification bodies (CB), which must comply with ISO / IEC 17065. The conformity assessment procedure [6] demonstrates to consumers, representatives of regulatory authorities and industry, etc. that the product meets the specified requirements, including, for example, product characteristics, its safety, functional compatibility and longer product lifetime [4]. Conformity assessment serves as a proof that the specified product requirements have been met and that the CB has carried out all necessary testing, control and certification [5–10].

Therefore, in order to improve the quality of the metamaterials conformity assessment (testing, verification, certification, and CB accreditation), it is necessary *to confirm the consistency of the specified conformity assessment requirements and to develop recommendations for their provision*.

The scheme for certification of metamaterials used both for metallurgical and engineering products includes conformity assessment operations and functions:

- selection, planning and preparation of actions, determination of requirements and products' sample selection [2].

- determination of the required number of product characteristics by testing [2, 11] or other types of work – process monitoring, involving technology verification and operation modeling [12, 13].

The greatest variety of technologies is used for metamaterials made of metals, alloys and composites (**Fig. 1**).

A large proportion of the technologies used are based on the methods of metallurgy and powder metallurgy. One of them is the method of directional melt impregnation. Superhard cermet composites are made according to the technology, which is based on the method of directional impregnation of superhard powder with a metal binder by contact method at high pressures and temperatures. Impregnation contributes to the improvement of the physico-mechanical characteristics of the metamaterial due to the elimination of porosity and the formation of new phases in the interaction of the impregnating melt with the superhard powder at high pressures and temperatures. Developing and improving this technology, for example, using alternating styling of the binder and the basics, or introducing a preliminary metallization operation, or combining original techniques [14], the possibilities and limits of the technology in powder metallurgy and in new areas of metamaterials, for example, were significantly expanded, metal-polymer composite materials.

The technical decision on the use of the polymer base of high-strength film adhesive as an adhesive binder for

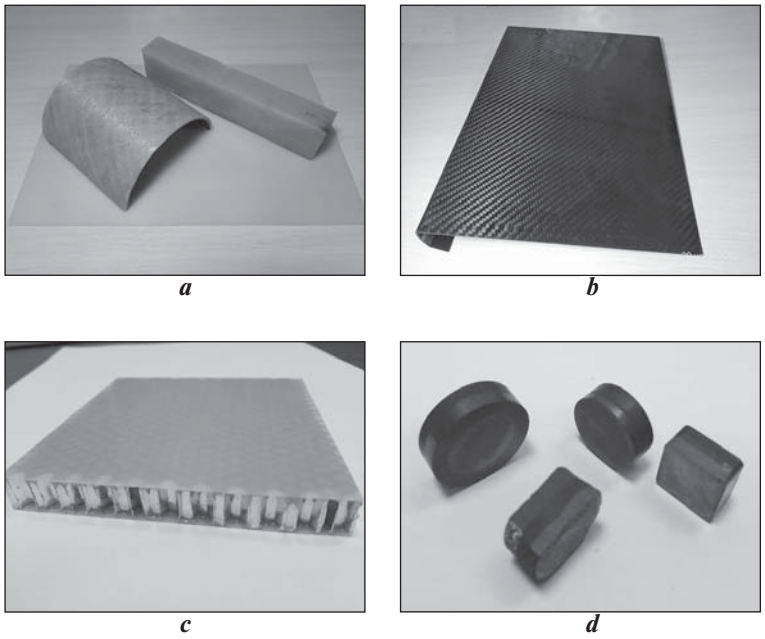


Fig. 1. Polymer composite material:
a — with glass filler; *b* — with carbon filler; *c* — metal-polymer composite material; *d* — made of ceramic-metal composite material

impregnating glass or carbon fillers in the manufacture of semi-finished prepreg with adhesive properties marked the beginning of the creation of fundamentally new materials — long-lived adhesive prepregs and composite materials (glass and carbon plastics) on them basis. On the basis of melt type adhesive binders (instead of mortar) with adjustable characteristics of viscoelasticity, strength, etc., and various domestic fillers — carbon fabrics, tapes, glass fabrics, including high modulus and quartz fibers — a range of glue prepregs was created grades KMKU (on coal fillers) and KMKS (on glass fillers) [15]. The effect of the elimination of porosity is manifested in what is achieved in 6–10 times higher tightness of the structure than with the use of mortar technology.

Such products are very diverse and come, inter alia, under such types of economic activities as: "metallurgical production, production of metals, their alloys, artificial crystals, as well as of products made of them, processing of metals and metal products"; "production of finished metal products"; and "production of composites".

Universities, especially basic or technological national ones (Tula State University), develop, research, produce, diagnose and test metamaterials (NITU "MISIS"). For this purpose, they usually have their own laboratory and a certification body (CB). They are created and operating on the basis of the university's legal entity, the Charter of which specifies their activities. On the other hand, the CB has an approved area of accreditation, which also contains a certain number of activities. These types of activities are overlapping because for the primary accreditation of the CB it is necessary to have a specific type of activity "technical testing, research, analysis and certification" in the Charter of the legal entity.

Therefore, if the Charter of the university contains activities concerning the production, research, analysis, testing and certification, etc., then the university-based CB has the same activities in its field of accreditation.

ISO/IEC 17065: 2012 specifies that when a legal entity proposes or manufactures certified products (or those that are subject to certification) or provides consulting services, CB executives and their personnel engaged in analysis and decision making should not participate in the activities of such a legal entity , and its employees — respectively in CB management, analysis or decision-making [6]. In addition, since the CB is part of a university that carries out a number of activities other than testing, evaluation and conformity assessment, the university management system clearly defines the responsibilities of administrative and management personnel that have an impact on the operation of the CB. With the help of corresponding organizational measures, the requirements of impartiality and independence from commercial, financial or other pressures are easily met if five or more experts work in the CB [16]. The quality manual and the documented information of the CB should first of all regulate the human factor that determines the correctness and reliability of certification and conformity assessment.

So, for example, when carrying out assessment of polymer composites manufacturing technology [17] and certifying their production, experts should pay special attention, first, to subdivision regulations, its organizational structure and personnel position descriptions. This is necessary to confirm the balance of tasks and functions of the subdivision and their implementation in the rights, functions and responsibilities of staff. Secondly, experts check the approved layout of the working area with indication of the existing equipment and storage facilities for inappropriate products. Thirdly, statistical data on product quality control, including analysis of internal spoilage and customer claims is important [18] (**Fig. 2**).

Almost any verification is the source of factors threatening the impartiality. The head of the CB should take into account the psychological and qualifying aspects of subordinate experts taking into account the following points.

When checking the input control of raw materials and components, the presence and condition of control, test, measurement tools must be assessed; availability and status of sampling techniques, monitoring and resulting documentation should be controlled; compliance of the incoming control with the requirements of regulatory documents should be checked.

When checking the storage of raw materials and components, the following issues should be assessed:

• storage conditions and intended use of the warehouse;

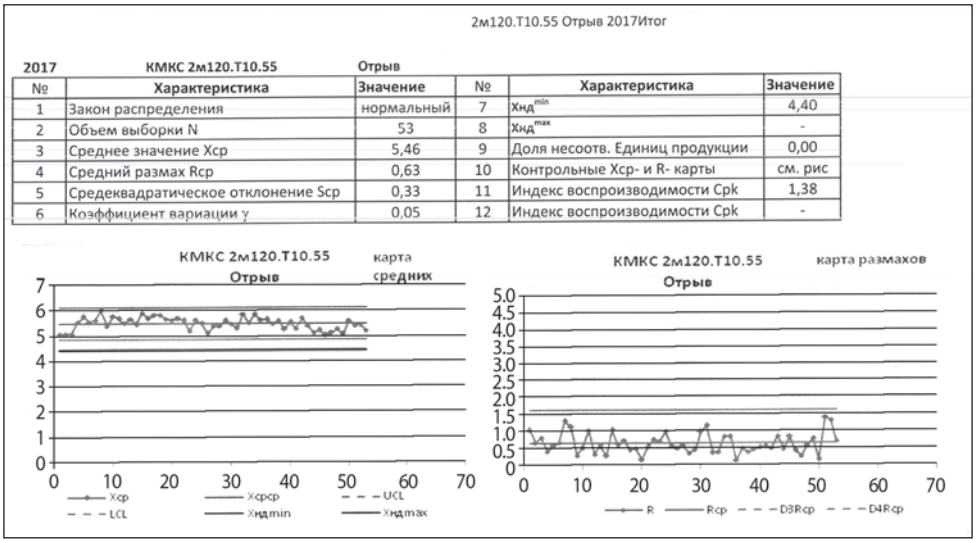


Fig. 2. Results of statistical processing of characteristics of mechanical properties of composite material of production of LLC NPF Tehpolikom, Moscow

• identification of the raw materials and components;

• compliance of the storage conditions of the raw materials and components with the documentation requirements.

When checking the state of basic and auxiliary manufacturing equipment, tools, rigging, control and measuring equipment in the subdivision, the following points are assessed:

• physical condition of equipment and devices, the presence of plates with the necessary inscriptions (name, registration number, checking periods);

• documenting and actual execution of procedures for repair, modernization, checking, etc. of equipment and tools;

• cleanness and order in the production facility, availability of unused materials, lighting, the condition of buildings, premises, floors and roofs, the condition of containers and intermediate warehouses, environmental conditions, etc.

When checking the actual execution of the technological process, the following issues are assessed:

• actual implementation of procedures;

• availability of the necessary documentation (or extracts from it) on working places and its quality;

• software, office equipment;

• compliance of the controlled technological parameters with established requirements [19];

• metrological support (calibrated and verified equipment and devices are used, calibration intervals are verified, calibration and verification status is provided, and verification date is stated on devices and equipment) [2];

• possibility of products traceability throughout the technological cycle, the registration of operations and necessary data into the accompanying documentation (melting practices sheets, registration passports, etc.) [9];

• performance of loading and unloading operations, transportation and product storage ensuring the preservation of its quality at production stages;

• availability of tools and means of measurement and control.

The assessment of quality conformity stability of the finished product with the specified requirements is carried out by:

• selective control of finished products;

• analysis of internal spoilage;

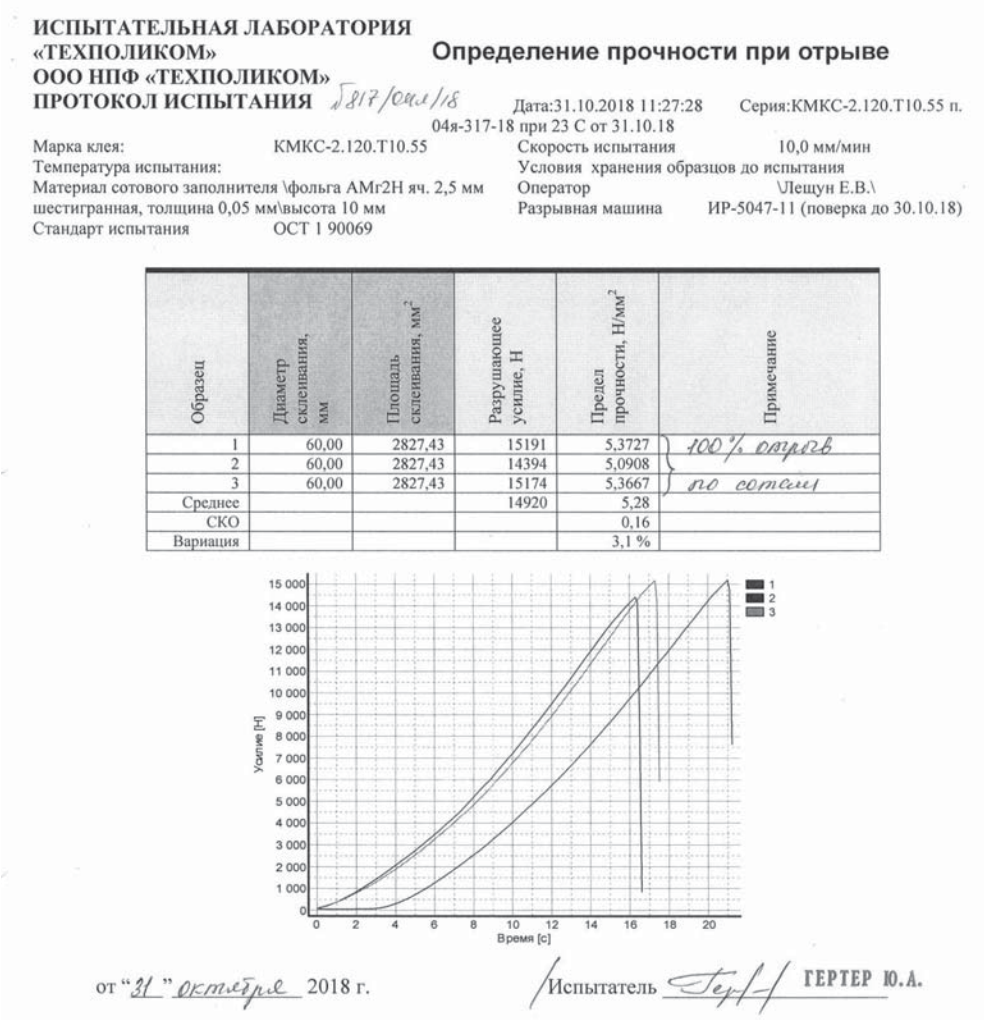
• analysis of claims and complaints of the Consumer (external spoilage).

Corporate culture and opportunities for professional growth of employees significantly affect the results of metamaterials quality assessment and technological process stability. These data, usually provided to the expert commission in the form of reports, before or during the production certification, should be analyzed by the members of the commission (the audit team) and can be checked by means of inspection of individual controlled parameters during the audit [18].

When creating databases on the technological parameters of production [13] and products' quality [7], it is necessary to provide for possible identification and traceability of suppliers of raw materials, melting and casting machines, homogenization furnaces, types of deforming equipment, production teams, heat treatment furnaces for production of each particular product [20].

All this requires the CB to manage the iterative process. As the contractual obligations for certification of metamaterials are being fulfilled, it is impossible to exclude new threats of impartiality and, accordingly, risks. For example, the risk may be caused by the imbalance in the interests of the parties arising during the certification process. Weekly monitoring of metamaterials' certification services quality, for example, at operational meetings of the CB, can provide high results: even the identification of a new risk itself can determine the responsible persons and their actions to respond to them.

Also, many years of experience in conformity assessment confirm the feasibility of such quality management



ИСПЫТАТЕЛЬНАЯ ЛАБОРАТОРИЯ
«ТЕХПОЛИКОМ»
ООО НПФ «ТЕХПОЛИКОМ»
ПРОТОКОЛ ИСПЫТАНИЯ 817/отл/18

Определение прочности при отрыве

Дата:31.10.2018 11:27:28 Серия:КМКС-2.120.Т10.55 п.
04я-317-18 при 23 С от 31.10.18

Марка клея: КМКС-2.120.Т10.55
Температура испытания:
Материал сотового заполнителя \фольга АМг2Н яч. 2,5 мм шестигранная, толщина 0,05 мм\высота 10 мм
Стандарт испытания ОСТ 1 90069
Скорость испытания 10,0 мм/мин
Условия хранения образцов до испытания
Оператор \Лещун Е.В.\
Разрывная машина ИР-5047-11 (поверка до 30.10.18)

Образец	Диаметр склеивания, мм	Площадь склеивания, мм²	Разрушающее усилие, Н	Предел прочности, Н/мм²	Примечание
1	60,00	2827,43	15191	5,3727	100% отрыв по сотам
2	60,00	2827,43	14394	5,0908	
3	60,00	2827,43	15174	5,3667	
Среднее			14920	5,28	
СКО				0,16	
Вариация				3,1 %	

от "31" октября 2018 г. Испытатель ГЕРТЕР Ю.А.

Fig. 3. Protocol testing Testing laboratories "Tekhpolikom», The certificate number AR MAK/CM/128/OR date of issuance 22.05.2017 G

system requirement as the existence of a system to ensure the independence and impartiality of the CB in the performance of activities and determination of requirements ensuring among other things the independence of the CB from manufacturers, sellers, performers and purchasers, including consumers [21]. This requirement is feasible if the Quality Manual has the item "Impartiality Management", which contains provisions on ensuring the independence of the CB from manufacturers, sellers, executors and purchasers, including consumers [22].

The Certification Body should have documents that contain rules ensuring compliance with the requirements for the CB, a legal entity that includes the CB, and stating that the specified persons should not act as designers, manufacturers, installers, sellers, operators or purchasers, as well as consumers of the products (works, services) that are subject to certification in accordance with the field of accreditation of the CB. Compliance with these accreditation requirements can be ensured by the availability of the following documents (rules): "Regulations on the CB"; Quality manual with the corresponding paragraph; procedure instruction "CB Impartiality Management"; "Impartiality Policy" [22].

Therefore, in the considered example of overlapping activities, documents for metamaterials conformity assessment, for example, test reports (**Fig. 3**), and conformity certificates, can legitimately be issued to applicants (legal entities), provided that the legal entity on the basis of which the CB is accredited and operating is not a consumer of products of the applicants (legal entities).

International standards and criteria for accreditation do not regard as a nonconformity the cases when the activities and objects of conformity assessment within the approved and declared for extension accreditation field of the certification body coincide with the activities contained in the charter of the legal entity, that contains the certification body.

From the legal meaning of these norms it follows directly that the Quality Manual of the certification body should contain:

- a system for ensuring the independence and impartiality of the certification body in carrying out its activities and determining the requirements that ensure the independence of the certification body from manufacturers, sellers, contractors and purchasers, including consumers;

- rules, ensuring compliance with requirements for the certification body, the legal entity or an individual entrepreneur, which includes the certification body and stating that the said persons should not act as designers, manufacturers, installers, sellers, operators or purchasers, as well as consumers of products (works, services) subject to certification in accordance with the accreditation area of the certification body.

The international standards and criteria for accreditation also specify the procedure for the periodic confirmation of the competence of the CB, at the end of which an Act of Expertise on the results of the accreditation criteria competence confirmation is issued.

The practice of holding a back up for unforeseen circumstances has been tested and effectively applied during many years of experience in conformity assessment. For example, if the final Expertise Report states that there is an inconsistency with the Accreditation Criteria — in terms of coinciding activities and the conformity assessment objects contained in the Charter of the legal entity and in the approved area of accreditation and with the requirements of ISO/IEC 17065:2012, ISO/IEC 17021:2011 [23] in the approved area of accreditation, the representatives of the CB can immediately use their right to sign the Expertise Report with the note that the CB has a special opinion (objections) regarding the content of the act; and then send an official letter with a statement of the Special Opinion (Objections to the Expertise Report on the results of the accreditation criteria competence confirmation).

It is worth mentioning here that the legal entity on the basis of which the CB is accredited and operating does not agree with the said conclusion of the expert group, considers it unreasonable and unlawful, since the expert group made such a conclusion based only on a formal approach to examination of the documents and information submitted to the CB, without delving into the very essence of the provisions of the accreditation criteria.

The international standards and criteria for accreditation state nothing about the overlapping types of activities contained in the Charter of the legal entity, containing the CB and the objects of conformity assessment in the approved area of accreditation.

Conclusion

In order to meet the requirements and Criteria for accreditation, the certification body that conducts conformity assessment of metamaterials, should ensure having the following documents: "Regulations on the CB"; Quality manual with the corresponding paragraph; procedure instruction "CB Impartiality Management"; "Impartiality Policy".

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