В роботі побудовано дерево показників якості пластмасових деталей. Запропоновано узагальнений алгоритм оцінки рівня якості пластмасових деталей, який є базою для розробки метода оцінки рівня якості пластмасових деталей. В розробленому алгоритмі, на відміну від існуючих, введено етап оцінки похибок рівня якості, що дасть можливість підвищити точність визначення якості пластмасових деталей

Ключові слова: комплексний метод, оцінка якості, показник якості, базовий показник, пластмасова деталь

В работе построено дерево показателей качества пластмассовых деталей. Предложен обобщенный алгоритм оценки уровня качества пластмассовых деталей, который является базой для разработки метода оценки уровня качества пластмассовых деталей. В разработанном алгоритме, в отличие от существующих, введен этап оценки погрешностей уровня качества, который даст возможность повысить точность определения уровня качества пластмассовых деталей

Ключевые слова: комплексный метод, оценка качества, показатель качества, базовый показатель, пластмассовая деталь

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DEVELOPMENT OF THE COMPREHENSIVE METHOD FORQUALITY ASSESSMENT OF PLASTIC PARTS

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1. Introduction

There is a rather wide nomenclature of plastic parts with different accuracy of dimensions, complexity in geometric shape, increased strength in contemporary instrument engineering. Volumes of the production of parts grow each day. The existing duration of the fabrication cycle of moulds (MD), 5–6 months on average, including the process of design from 1 to 3 months, becomes ever more unacceptable. Hence it follows that it is very importantto reduce the cycle of technological preparation for production by automating the designing process ofmoulds, which will make it possible to increase the competitiveness of plastic parts (PP) [1].

Special attention when designing PP must be paid to:

– the choice of parameters forthe technological process of plasticinjection molding, which depend on the condition of equipment;

– analysis of parameters of the process of «physical transformation» of molten plastic into a solid body;

– towarrant dimensions of articles with regard to the shrinkage of material, etc.

The concept of PP «quality»includesa totality of properties, which specify its applicability to meet certain requirements that match the purpose of the part [1–6].

At present, there are a number of methods to assess quality (Fig. 1) [8–12].

These methods are mostly applicable for obtaining and evaluating those indicators, the knowledge of which is necessary to successfully use the plastics as construction materials. The methods (Fig. 1) are not entirely responsibe for «high quality» of PP, because many of them «appeared» due to solving particular problems without any scientific substantiation, while others were developed based on the known methods, employed for metals.

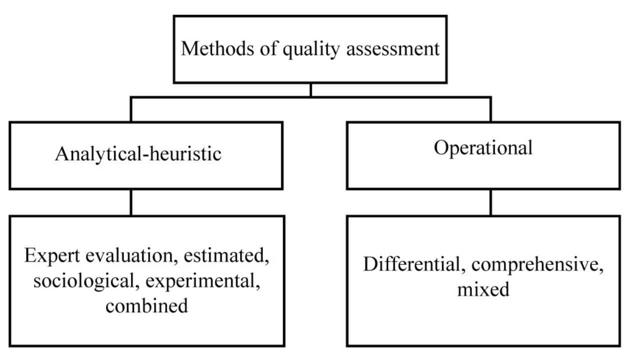

Fig. 1. Classification of methods for quality assessment

At present, PPs are actively promotedin the world market place. Obtaining quality PP directly depends on the methods of assessing their quality. Therefore, the task of devising acomprehensive method for evaluating quality of plastic parts is very important.

2. Literature review and problem statement

The basic principles for determining quality of plastic parts are found in articles [7–9].

In [2], quality was defined as:

– the quality of production is determined by total losses for society, and the magnitude of these losses (quality loss function) is proportional to the squareof deviation of product qualtityindicatorfrom the nominal;

– goods, processes, services under development should demonstrate robustness (stability) relative to the possible external impacts and have minimum spread of indicators relative to the nominal;

– minimization of the quality loss function and creation of robust product (process, service, etc.) is accomplished by the methods for planning an experiment.

[2] introduceda concept of the quality loss function (QLF). QLF makes it possible to link technical parameters of PP shapingto the cost indicators.

Development of the PP fabrication processes, examining influence of the technological process on the quality of casting parts is presented in [5, 6].

In [8], main attention is paid to the development and evaluation of studies aimed at improving quality when designing new products and technological processes. [9] examined problems of materials quality, issues aboutcontrol over technological processes, but did not consider problems related tothe quality of mould design. [10, 11] investigated methods forassessing quality and presented fundamental relationships for determining basic quality indicators, but error in determining the QL values was not taken into account.

Quality management at the industrial enterprise, quality of production for military purposes, quality management economics are described in [12].

[13] examined questions linked to the optimization of parameters of injection molding from polypropylene with the use of Tagutti method. However, [12, 13] did not pay attention to moulded parts from plastics of the thermoplastics type.

In [14], authors focus on the examination of the data collection system Rapid, but they do not tackle how tosolvethe problem on selecting basic indicators of PP quality.

The issues relatedto quality control over the processes of plastic partsmoulding are examined in [15]. [16] described basic stages of quality control over injection molding in real time; however, the optimization stages of technological parameters of casting process of plastics of the thermoplastics type are insufficiently defined.

Article [17] is devoted to examining the process of changing theproperties of plastic during injection molding of parts and the use of statistical control over production processes. [18] explored parameters of the injection molding process. A process of performing imitation simulation isdescribed, but the process of optimization of the casting parameters, which influence QL of plastic parts, is not described.

The simplest and effective method to control quality of parts is the visual control of exterior view without using magnifying instruments. Each article is subjected to such test for detecting the faulty parts, for example, with cracks, tbubbles or other visible defects. In certain cases, they prepare control models with different kinds of defects to compare, part of which can be considered acceptable as those that do not affect quality and performance properties of articles. In contrast to the parts made of traditional materials, PP that have defects unaccepatable in appearance are not subject to correction, they are rejected and discharged as waste.

When controlling the dimensions of plastic parts, it is necessary to consider special features of the material [19, 20]. High coefficient of linear expansion of the material can cause errors from thermal deformations. Low rigidity of parts results in additional increase in errors from the measuring effort [1].

The optimization of plastic part quality does not always depend on the quality:

– of materials, semifinished products or billets;

– of personnel at the work site performing all the required operations.

The largest effect can frequently be achieved as a result:

a) of change in the design of technological equipment;

b) ofdetermining correctlythe operations of technological process and parameters of the parts under control.

Lack of sufficient definition of quality indicators for the components of radio-electronic equipment, their peculiarities and characteristics, necessitates conducting studies in this direction.

3. The aim and tasks of the study

The aim of present study is to improvequality of plastic parts by increasing the accuracy of assessment in the process of design and fabrication.

To achieve the set aim, the following tasks were to be solved:

– to analyze development and evaluation of studies, directed toward improving quality of designing new plastic parts;

– to examine impact of MD parameters and the casting technology on quality;

– to propose a new approach for the comprehensive assessment of quality indicators of plastic parts;

– to devise an algorithm for the estimation of plastic part quality;

– to construct a tree of basic indicators of PP quality (casts).

4. Development of a comprehensive method forassessingquality indicators of plastic parts

An analysis of designing PP and constructing moulds for the injection molding allowed us to develop an algorithm for assessing PP quality indicators based on the»comprehensive approach» that ensures quality of fabrication. A variety of the quality indicators (QI) for plastic parts demonstrates the lack of a unified approach regarding PP quality, complexity of their classification and difficulties with their asessment. The absence of possibility of developinguniform requirements to the plastic partsaffects methods of their assessment. Particular properties are expressed by a single quality indicator (these are admittances for the dimensional coefficients of roughness and surface waviness, permissible deviations from geometric shape and mutual arrangement of surfaces, product appearance) [1, 12, 15].

Present work is based on the theory of Philip Crosby (USA). In other words, quality is the degree of conformity of all peculiarities and characteristics of articles to the technical specifications.

By the definition, quality assessment is represented as a four-component model – estimation system

$$S_{ok} = \langle S, O, B, L \rangle,$$

where S is the subject of estimation (consumer); O is the object of estimation (part); B isthe base for comparison (estimation base); L is the algorithm of estimation.

Underlying the developed method is the proposed algorithm for the estimation of quality level of plastic parts (Fig. 2).

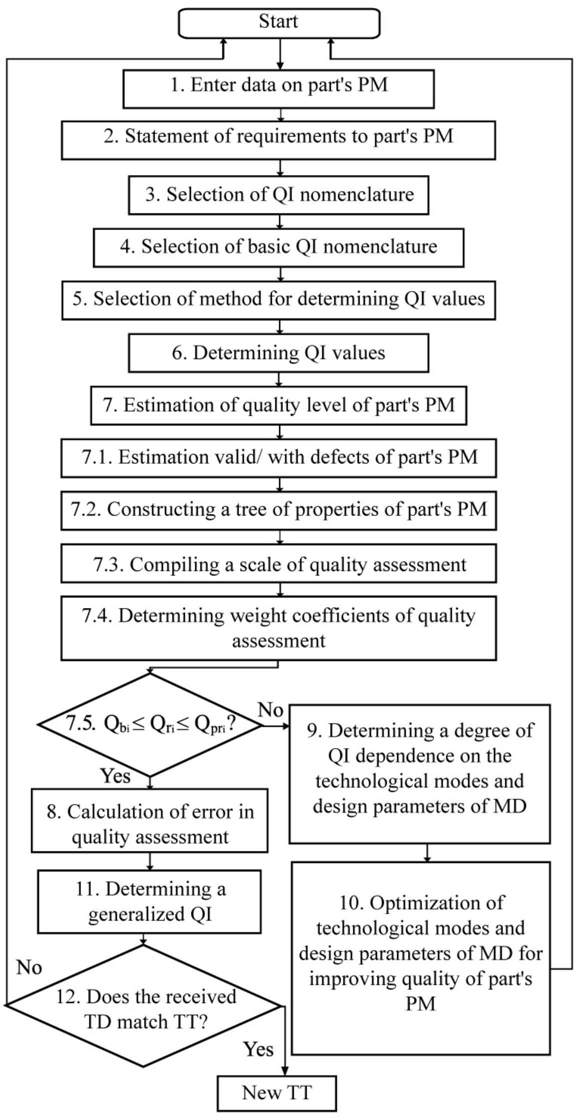

Fig. 2. Generalized algorithm for the estimation of PP quality

Stage 1. A process of making a technical decision (TD) to improve in quality starts from the operation of searching for solutions in the array of accumulated experience of information data bank. If the solutions are found, then we enter information, if not, data downloading is repeated.

Stage 2. Statement of requirements to PP. It is important to correctly formulate requirements to PP. It is proposed to divide the requirements, put to the consumer qualities of contemporary parts, into three basic groups:

– purpose;
– reliability;
– esthetic value.

Basic requirement is theworkability of PP.

Stage 3. Selection of the nomenclature of QI of parts. The selection was conducted based on:

– determining the purpose and usage conditions of PP;
– analysis of demands from consumers;
– composition and structure of the characterized devices;
– basic requirements to QI.

Hence, a list of PPquality indicators is determined: roughness, density, strength, hardness.

Stage 4. Selection of the nomenclature of basicquality indicators of PP. The listof basic QI is structured in accordance with the classification of indicators and is represented in the form of the tree of PP quality indicators PP (Table 1). In Table 1, the overall sizes of shaping parts are designated as (SP).

Table1

Tree of basicPP (casts) quality indicators

0-level	1-level	2-level	3-level
Basic quality indicator	1. Indicators of purpose	Indicators of article fabricated in MD	Width (B)
			Length (L)
			Cast volume(V)
			Wall thickness H(S)
			Dimension precision, quality factor
		MD indicators, MD blocks	Dimension precision
			WidthSP (B)
			LengthSP (L)
			HeightSP (H)
	2. Esthetic indicators	Product appearance	Shape
			No caves
			No chips
			No blistering
			No cracks
			No scratches
			No difference in thickness
0-level	1-level	2-level	3-level
	3. Reliability indicators	Durability	Gamma percent service life
			Assigned full service life
		Failsafe	Gamma percent work till failure
			Mean failure-free operation

At the zero level of the tree is a basic QI, which is formed based on QI of the 1 level, which in turn includes groups of 2, 3, 4 levels.

Stage 5. Selection of method for determining the values of PP quality indicators.

In the present study, we propose a comprehensive method, which includes measuring and calculated methods. This method will allow us to carry out objective evaluation, as well as representthe results in the conventional measurement units, which is convenient for the comparability and reproducibility of results. In contrast to those existing, the method will demonstrate low labor intensity, relatively small error and reliability of the obtained results.

Stage 6. Determining values of PP quality indicators.

Fragment of the algorithm fordetermining the values of QI is represented in Fig. 3.

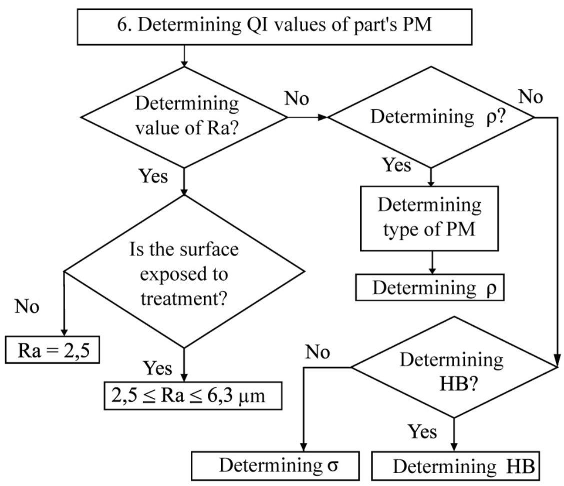

Fig. 3. Fragment of determining the values of QI

Assume Ra is arithmetic mean value of deviation of profile; ρ is the plastic density, determined by measuring the dimensions and by weighing; HB is the hardness of PP whose calculated ratios are given in [6].

The values of relative and basic QI are determined in [21].

Stage 7. Estimation of PP quality level.

Stage 7. 1. Initially it is proposed to estimate parts as-non-defective/defective. If a partis rejected, then we shall evaluate according to the number of revealed defects. As a result, we tested if the basic requirement to PP was met – test for the workability.

Assume the PP quality is described by p independent attributes. Then results of control can be written down in the form of p-dimensional random vector $x=(x_1, x_2,...,x_p)$. Each component of this vector is assigned with value $x_j=1$ if there is a defect by the j-th attribute, and 0 – if the defect is missing. The task of control is the estimation of quality of the entire batch of components based on the control of its sample. Since the control is executed by several attributes at the same time, then quality of the batch can be estimated in two ways:

1) according to the number of defective parts;

2) according to the number of revealed defects.

In order to evaluate quality, we shall introduce expressions:

$$b=\sum_{j=1}^{p} c_j x_j, \qquad (1)$$

where c_j are the weight coefficients, j=1...p, p is the attribute of part's quality; $x_j=1$, if the article is defective by the j-th attribute and $x_j=0$ – otherwise.

Plastic part is non-defective if the inequality is correct

$$b=\sum_{j=1}^{p} c_j x_j \le b_0, \qquad (2)$$

where b_0 is the threshold of defectiveness, established with consideration of interests of supplier and consumer.

After the non-defective parts are after determined, let us find separate relative quality indicators of the examined part, which we shall determine as follows. Since the values of quality indicator shavecertain limitations:

$$K_i=\frac{Q_{r_i}-Q_{pr_i}}{Q_{b_i}-Q_{pr_i}}, \qquad (3)$$

where Q_{r_i} is the value of the i-th quality indicator of the evaluated PP; i=1,2,...,n (n is the number of quality indicators accepted for estimation); Q_{b_i} is the value of the i-th quality indicator of basic model; Q_{pr_i} is the limiting value of the i-th parameter of quality.

Stage 7. 2. Construction of the tree of all PP properties [21].

Stage 7. 3. Compiling a scale for the estimation of quality.

Central place in the procedure of evaluation is occupied by the construction of qualimetric scales. In order to evaluate quality level, it is proposed to use the scale of relations – this isa measuring scale, on which one defines numerical value of the measured magnitude K_i as a mathematical relation:

$$K_i=\frac{Q_{r_i}}{Q_{b_i}}, \qquad (4)$$

$$K_i=\frac{Q_{b_i}}{Q_{r_i}}. \qquad (5)$$

In contrast to the scale of differences, the scale of relations does not have negative values.

It is necessary to select the formula, in which an increase in the relative indicator K_i corresponds to an improvement in quality of the plastic part. Thus, for instance, for the indicator of mechanical strength they use (4), and for indicators of the level of nonconformities (defects) – (5).

In the construction of scale forquality estimation, there may be the following variants Fig. 4, *a–c* [12, 22].

In Fig. 4, *a* all values K_i are larger than unity (referencelevel), therefore, the level of quality of the evaluated PP is higher than the basic one.

In Fig. 4, *b* all values $K_i$are less than unity; therefore, the level of quality of the evaluated PP is lower than the basic one.

In Fig. 4, *c*, if one part of K_i is larger than unity, and one part is less, then it is not possible to unambiguously estimate the level of PP quality.

When a part ofrelative indicatorsis larger or is equal to unity, and another part is less than unity, it is necessary to use first of all the following method for evaluating the quality level. It is necessary to divide all relative indicatorsby their significance into two groups. The first group includes those indicators, which characterize the most important properties, and the second one – those secondary ones. If in the first group all relative indicatorsare larger or are equal to unity, then it is possible to consider that the level of quality of evaluated PP is not lower than the quality level of the basic model.

Stage 7. 4. Determiningweight coefficients of the estimation of quality.

For determining the rating of importance, we use scale from 0 to 1; 1 is the high significance.

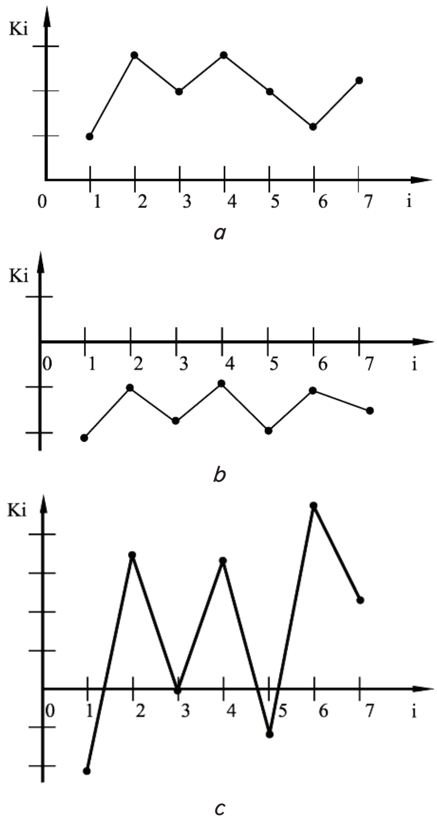

Fig. 4. Example of comparing the part's quality indicators according to the scale of relations: *a* — all values K_i are larger than unity (referencelevel); *b* — all values K_i are less than unity; *c* — one part of K_i is larger than unity, and one part is less

Stage 7. 5. Testingthe conditions (quality criteria) Q_{r_i} – the value of the*i*thquality indicator of the evaluated PP must be in the range $Q_{b_i} \le Q_{r_i} \le Q_{pr_i}$. If the condition is satisfied, then point 7. 5 is fulfilled – the estimation of error in quality level. If the condition is not satisfied, then we proceed to point 9.

Stage 7. 5. 1. Determining the dimensions of PP. Dimensions of plastic partsmust be in the range

$$D_{b_i} \le D_{r_i} \le D_{pr_i},$$

where D_{r_i} are the dimensions of PP at i=1...4.

Assume that 4 is the number of parameters, which determine the dimension of PP:

1 – width (B);

2 – length (L);

3 – casting volume (V);

4 – wall thickness H(S).

Optimum thickness of wall of the parts made of thermoplastic plastics is from 0.8 to 4 mm, for the small-dimensional ones – 0.4 mm. Determining the lowest permissible thickness of walls of the articles is possible using formula

$$S = 0.8\left(\sqrt[3]{h} - 2.1\right), \qquad (7)$$

where his the height of wall of the part.

Upon determining the dimensions of PP (stage 7. 5. 1), we proceed to stage 7. 5. 2.

Stage 7. 5. 2. Determining the accuracy of dimensions of PP (degree of quality) [23].

We recommend assigning the accuracy of dimensions of plastic parts within the range of classes 5–7.

Upondetermining the accuracy of plastic parts, it is necessary to determine accuracy for MD. It is defined similar to that of PP [23]. Then we proceed to stage 7. 5. 3.

Stage 7. 5. 3. Determining the overall sizes of all shaping elements ofMD [24]. Upon completion of this stage,we proceed to stage 7. 5. 4.

Stage 7. 5. 4. Determining thefailure-free performance and durability ofPP [25]. Upon completion of this stage, we proceed tostage 7. 5. 5.

Stage 7. 5. 5. Determining the surface roughness for PP (thermoplastics): can be assigned $H_a = 1{,}0 \div 0{,}04$ µm. Roughness of the surface of plastic parts, made by injection molding and extrusion, corresponds to classes 7–8 [23]. Upon completion of this stage,we proceed to stage 7. 5. 6.

Stage 7. 5. 6. Determining the strength, density and hardness [25].

If the values of quality indicators of the evaluated PP, determined as a result of fulfillment of stages 7. 5. 1–7. 5.6, are in the range $Q_{b_i} \le Q_{r_i} \le Q_{pr_i}$, thenwe proceed to stage 8. If not – we proceed to stage 9.

Stage 8. Calculation of error in determining thequality of PP:

$$\Delta K_0 = \Delta K_{prop} + \Delta K_{weight} + \Delta K_{wear} + \Delta K_{calc} + \Delta K_{instr}, \qquad (6)$$

where ΔK_{prop} is the error in the number of properties, which characterize quality; ΔK_{weight} is the error in determining the weight coefficients; ΔK_{wear} is the wear and aging of the materials, which the MD are made of; ΔK_{calc} is the error in the calculations of quality indicators; ΔK_{instr} are the permissible instrument errors.

Stage 9. This stage should be carried out in order to correct the values of QI. First, determine the degree of dependence of QI on the technological modes and design parameters of MD according to Table 2.

These factors influence the quality of PP:

1) Davlv – melt injection pressureand Davlvd – holding pressure;

2) Tempv – the casting process holding temperature;

3) Tempf – temperature of MD during casting;

4) Tempr – temperature of melt during casting;

5) Timev – curing time;

6) Timec – casting cycle period;

7) MD – the mould that consists of the systems: shaping parts, pushing parts, centering, cooling and ventilation, funnels.

Afterwe determined those parameters thatneed correction, we proceed to stage 10.

Stage 10. Optimization of the technological modes of casting and design parameters of the mould.

The highest PP quality is reachedat simultaneous optimization of the technological modes and design parameters of MD [8, 26–28].

In the course of optimization of technological modes, it is necessary that the following conditions be satisfied:

1. Temperature of the melt:

$$t^o{}_{pl} \le t^o{}_p \le t^o{}_{pd},$$

where $t^o{}_{pl}$ is the temperature of plasticization of plastic; $t^o{}_{pd}$ is the temperature of destruction of plastic.

Table 2

Dependence of QI on the technological modes and design parameters of MD

Factor that affects the quality of MD										
Quality indicators		QI name	Davlv	Tempv	Tempf	Tempr	Timev	Timec	Davlvd	MD
		PP dimensions	+	–	+	+	+		+	+
		PP dimension precision, quality factor	–	–	+	–	–	–	–	+
		PP failsafe	–	–	–	–	–	–	–	–
		PP durability	–	–	–	–	–	–	–	–
		PP shape	–	–	–	–	–	–	–	+
	Product appearance	No caves	–	+	+	+	+	–	+	+
		No chips	–	–	–	–	–	–	–	+
		No blistering	–	+	–	–	–	–	–	+
		No cracks	–	–	+	–	+	+	–	+
		No scratches	–	–	–	–	–	–	–	+
		No difference in thickness	+	–	+	–	–	–	–	+
		Roughness	+	–	+	–	–	–	–	+
		Density	+	+	+	+	+	–	+	–
		Strength	–	+	+	+	+	–	–	–
		Hardness	+	–	–	–	+	–	–	–

Note: «–» denoteslack of interrelation; «+»denotes existence of interrelation

2. Temperature of MD:

$$t^{o}_{cool} \le t^{o}_{md} \le t^{o}_{ts},$$

where t^{o}_{cool} is the temperature of plastic cooling; t^{o}_{ts} is the temperature of thermal stabilization.

3. Casting pressure:

$$Davl \le Davl_{bv},$$

where $Davl_{bv}$ is the boundary value of pressure for the selected automatic thermoplastic machine.

Upon completing stage 10, we proceed to stage 1. The cycle is repeated anew until the values of quality indicators of the evaluated PP are in the range $Q_{b_i} \le Q_{r_i} \le Q_{pr_i}$.

Stage 11. Determining a generalized indicator of quality for PP.

Since the part is non-defective (defects-free), we shall determine a generalized quality indicator, which will include:

– minimumresulted expensesat change in the MD design:

$$E = \min\left(\sum_{i=0}^{I} Z_i v_i + \sum_{j=0}^{J} \sum_{j=0}^{J} Z_{ij} x_{ij} \right), \qquad (8)$$

where Z_i are the expenses for the i-th change, caused by the addition/by the removal of the appropriate element in the MD design; $v_i=1$ if there is the ithdifference from the prototype; Z_{ij} are the expenses for the modification of MD designwhen adjusting theithand the j-th elements of the MD design; $X_{ij}=1$, if there is a need to modiy the j-th element of the MD designat theith change in the design; $x_{ij}=0$ – other wise.

– minimum resulted expenses at change in the technology of casting. This criterion is determined under condition that the existing rigging has already been used. It is determined similar to (8).

– minimum labor intensityat change in the MD design:

$$F = \min\left(\sum_{i=0}^{I} T_i v_i + \sum_{j=0}^{J} \sum_{j=0}^{J} T_{ij} x_{ij} \right), \qquad (9)$$

where T_i is the labor intensity of the i-th change, caused by the addition/by the removal of the appropriateelement of the mould (MD) design; T_{ij} is the labor intensity of the modification in the MD design when adjusting the i-th and the j-th elements of the MD design;

– minimum labor intensityat change in the technology of casting. It is determined similar to (9);

– maximumprecision of PP:

$$K = \max\left(\sum_{i=0}^{I} W_i v_i + \sum_{j=0}^{J} \sum_{j=0}^{J} W_{ij} x_{ij} \right), \qquad (10)$$

where W_i is the improvementof precision ofpart's PM due to the i-th change, caused by the addition/by the removal of equivalent element; W_{ij} is the increase/the decrease inprecision ofpart's PMdue to the modification in the MD designwhen connecting theithand the j-th elements of the MD design.

Constraints:

1) accuracy of the i-th change must exceed the assigned W_a:

$$\sum_{i=0}^{I} W_i v_i + \sum_{j=0}^{J} \sum_{j=0}^{J} W_{ij} x_{ij} \ge W_a;$$

2) the cost of the i-th change must not exceed the assigned Z_a:

$$\sum_{i=0}^{I} Z_i v_i + \sum_{j=0}^{J} \sum_{j=0}^{J} Z_{ij} x_{ij} \le Z_a;$$

3) the labor intensity of the i-th change must not exceed the assigned one:

$$T_a \sum_{i=0}^{I} T_i v_i + \sum_{j=0}^{J}\sum_{j=0}^{J} T_{ij} x_{ij} \le T_a.$$

Stage 12. The final stage is the evaluation of conformity of the obtained solution to the initial statement of the problem in the technical task. If the solution complies with the technical task (TT), then the new technical solution is obtained. If it does not match TT, it is necessary to repeat the entire cycle.

5. Discussion of results of examining the comparison of the PM quality indicators on the example of the part «planar smooth insulator with acontour and convex grooves»

In order to verify obtained results and adequacy of the method proposed, we shall conduct studies on the planar smooth insulator with a contour and convex grooves, shown in Fig. 5. We selected 9 standard QI, which are the most characteristic of the given parts. The sampling is limited by the impact of the chosen indicators on the part's quality.

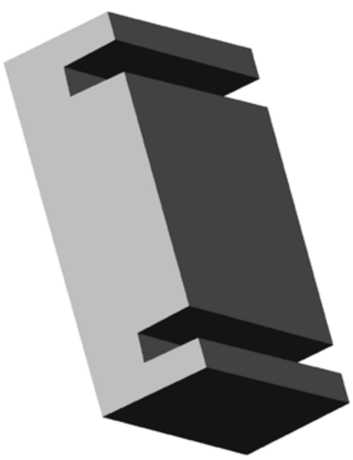

Fig. 5. Planar smooth insulator with a contour and convex grooves

Data on the results of calculations for evaluating the quality indicators of PP are represented in Table 3.

Results of comparison are given in the form of chart in Fig. 6.

Fig. 6 shows that a part of the values of quality indicators (1, 2, 4, 7) correspond to the required level of quality. Indicators 3, 5 and 8 do not correspond to the required level of quality, which, on the one hand, does not make it possible to unambiguously estimate the level of quality of the insulator by these indicators. These parameters should be optimized to achieve the required level of quality. From the other hand, due to the method proposed, we obtained the more precise values of such indicators as Brinell hardness and roughness. Thus, employing this method improved the quality of plastic parts, due to the increase in accuracy of indicators 6 and 9.

The problem on evaluating the quality indicators of parts is reduced to the task on the comprehensive assessment of plastic parts QI, which is essentialya comparison of the evaluated part tothe base model. The obtained results allow the manufacturer to determine the most important parameters of PP from the point of view of the consumer, as well as determine effectiveness of own potential competitive advantages.

Table3

Quality assessment of the planar smooth insulator with a contour and convex grooves

No.	Indicator		QI basic value	QI value by the results of calculation	Relative indicator
1	PP dimens-sions	width (B), mm	40	40	1.0
2		length (L), mm	60	60	1.0
3		casting volume (V), cm^3	96	97	0.9
4		wall thickness H(S), mm	1	1	1.0
5	PP dimension precision, quality factor		6	5	0.8
6	Roughness, R_a, µm		0.1	0.09	1.1
7	Density, g/cm^3		0.96	0.96	1.0
8	Tensilestrength, MPa		60	63	0.95
9	Brinell hardness, MPa		52	56	1.1

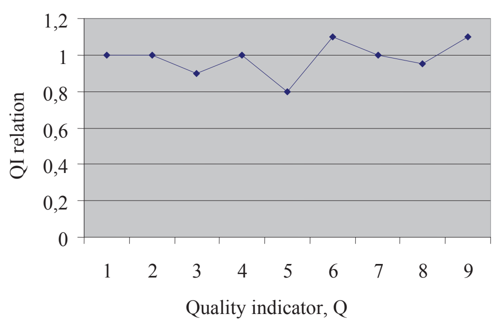

Fig. 6. Comparison of quality indicators of planar smooth insulator by the scale of relations

The benefit of the developed method is in the fact that it, in contrast to those existing, considers:

– labor intensity at a change in the MD design;

– labor intensity at a change in the technology of casting.

The shortcomingsincludea constraint in the method proposed – the material of the part is thermoplastics only.

The designed method is useful in the development of mathematical and CAD softwarefor technological equipment. It might be applied in the fabrication of thermoplastic parts for radio-electronic equipment.

In future, it is planned to improve the method proposed byforming the levels of quality profile.

7. Conclusions

1. The devised algorithm is the basisfor the method to evaluate quality of the plastic part. The algorithm contains a developed sequence of stages for determiningthe quality of plastic parts and for identifying the parameters of technological process of shaping plastic parts and elements of the moulds, which directly affect quality of the part.

2. A tree of the basicquality indicators of PP (casts) is built. The tree was constructed based on the requirements that are compiled from the normative and technical documentation. At the zero level of the tree is a base QI, which is formed based on QI of level 1, which, in turn, include groups of levels 2, 3, 4. The constructed tree allowed us to establish a nomenclature of the basicindicators of quality, which are used for evaluating the quality of plastic parts.

3. A comprehensive method of evaluating the quality of plastic parts is developed. Its essence is in the fact that the obtained method makes it possible to determine the comprehensiveindicatorof quality of plastic part, which includes:

– proposed nomenclature of quality indicators, represented in the form of the tree;

– proposed generalized indicator of quality of plastic part.

The designed method makes it possible to improve quality of plastic articles due to an increase in the accuracy of estimation of the selected parameters in the process of design and fabrication. The developed comprehensive method differs from those existing by the proposed additional stage – assessment of error in quality. Its essence is that it is necessary to determine:

– error in the number of properties that characterize quality;

– error in determining the weight coefficients;

– wear and aging of the materials that the MD are made of;

– error in the calculations of quality indicators;

– permissible instrument errors.

All these enumerated components will, in turn, make it possible to increase accuracy in the quality assessment of plastic parts.

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ANALYSIS OF THE MODEL OF INTERDEPENDENCE OF THERMOELEMENT BRANCH GEOMETRY AND RELIABILITY INDICATORS OF THE SINGLE-STAGE COOLER

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Розглянуто вплив геометрії гілок термоелементів на основні параметри і показники надійності однокаскадного термоелектричного охолоджуючого пристрою для різних перепадів температури при тепловому навантаженні 2,0 Вт для характерних режимів (Q_0/I)max і (Q_0/I^2)max. Показано, що для різних перепадів температури при зменшенні відношення висоти гілки термоелемента до площини її поперечного зрізу інтенсивність відмов зменшується

Ключеві слова: термоелектричний охолоджуючій пристрій, показники надійності, перепад температури, геометрія термоелементів

Рассмотрено влияние ветвей термоэлементов на основные параметры и показатели надежности однокаскадного термоэлектрического охлаждающего устройства для различных перепадов температуры при тепловой нагрузке 2,0 Вт для характерных режимов $(Q_0/I)_{max}$ и $(Q_0/I^2)_{max}$. Показано, что для различных перепадов температуры при уменьшении отношения высоты ветви термоэлемента к площади ее поперечного сечения интенсивность отказов уменьшается

Ключевые слова: термоэлектрические охлаждающее устройство, показатели надежности, перепад температуры, геометрия термоэлементов

1. Introduction

The problem of improving reliability of thermoelectric coolers used in electronics thermal condition control systems remains the pressing problem because of permanently toughening requirements to the present-day land-based and on-board equipment. Improvement of reliability indicators of thermoelectric coolers is realized according to various principles at various steps:

– in design engineering: according to parametric and design approaches;

– in production: by technology development;

– in operation: by selection of operation conditions.

2. Literature review and problem statement

Considerable attention to analysis of the problems of reliability of thermoelectric coolers [1, 2] is paid because viability of the entire system is directly determined by the working capacity of critical heat-loaded elements. The parametric approach is based on choosing thermoelectric materials [3, 4]