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ENSURING ACCURACY OF GYROSCOPIC SYSTEMS. MODERN METHODS AND APPROACHES

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ОБЕСПЕЧЕНИЕ ТОЧНОСТИ ГИРОСКОПИЧЕСКИХ СИСТЕМ. СОВРЕМЕННЫЕ МЕТОДЫ И ПОДХОДЫ

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In the modern world the interference in production exact instrument making requires more and more. Precision instrument making one of the most important components of scientific and technical progress. The instruments which are a part of different systems and complexes on traffic control, instruments of navigation and orientation, instruments of sea navigation, space, aviation instruments and so on. At the same time quality of execution of such instruments which are manufactured of the modern materials and is combined by elements of exact mechanics, optics, high-voltage electronics, and determine the instrumental accuracy, reliability and a resource of operation of complexes. Gyro instruments bright representatives of products of exact instrument making are also used both in systems of navigation, and in the navigation systems without platform and stabilizing of spacecrafts. Accuracy and reliability of the modern gyroscopic systems in many respects depend on stability of the form, the geometrical sizes, durability of materials and methods of receiving materials of the details which are a part of construction of high-precision nodes. In this operation methods and methods of support of accuracy of gyroscopic systems depending on the used material in details namely for an alloy 40HNYU-VI will be considered.

В современном мире все больше требует вмешательство в производство точное приборостроение. Точное приборостроение одно из важнейших составляющих научно-технического прогресса. Приборы, входящие в состав различных систем и комплексов по управлению движением, приборы навигации и ориентации, приборы морской навигации, космические, авиационные приборы и так далее. При этом качество выполнения таких приборов, которые изготавливаются из современных материалов и сочетают в себе элементы точной механики, оптики, высоковольтной электроники, и определяют инструментальную точность, надежность и ресурс работы комплексов. Гироскопические приборы яркие представители изделий точного приборостроения и используются как в системах навигации, так и в бесплатформенных системах ориентации и стабилизации космических аппаратов. Точность и надежность современных гироскопических систем во многом зависят от стабильности формы, геометрических размеров, прочности материалов и способов получения материалов деталей, входящих в состав конструкции высокоточных узлов. В данной работе будут рассмотрены методы и способы обеспечения точности гироскопических систем в зависимости от использованного материала в деталях, а именно, для сплава 40ХНЮ-ВИ.

The modern technological level of precision instrument making defines application in different constructions of the metal materials satisfying to a difficult complex of physics and mechanics properties: high mechanical characteristics, corrosion resistance, the required coefficient of thermal extension, sized stability in time.

The group of precision precipitation hardening alloys with the given properties of elasticity meets these requirements for set of indices in the greatest measure. Among alloys of this group the alloy 40HNYU-VI which is characterized by high resistance to micro plastic strain and relaxational firmness in the conditions of static and cyclic loading that is especially important for saving the sizes of high-precision details of products of exact instrument making is selected. Alloy 40HNYU-VI is widely applied in case details and responsible precision nodes with a manufacture accuracy at the level of units and the tenth shares of a micrometer of different gyro instruments and systems: gyroscopes, accelerometers, borehole modules of orientation and so on.

Characteristic product of exact instrument making in which the modern constructional materials are used and direct dependence between the accuracy and reliability of the instrument and sized stability of the entering high-precision nodes takes place, the two-degree floated type gyroscope — the precision sensor of angular information representing a product in which casing the hermetic float containing the fast-rotating rotor is weighed in viscous liquid is. The hemispherical gas bearing which material of details is an alloy 40HNYU-VI is used to weighing of a rotor which sets the principal axis of sensitivity of a gyroscope [1].

Strict requirements on manufacture accuracy at the level of the tenth shares of a micrometer, and according to the tolerance of sized instability in time - thousand shares of a micrometer in an hour are imposed to details and a node in general of the precision gas bearing of a floated type gyroscope. These requirements are necessary for saving persistence of a lubricant gap of a gas suspension, support of instability of leaving of the instrument from deformations of a suspension (support flange) less than 0,001 ° / h for an hour that directly determines the functional accuracy and operational reliability of a gyroscope and, as a result, competitiveness of products.

Technological processes of manufacture of details of the gas bearing have two important features: execution on details of several precision rigidly interdependent surfaces and formation on the working surfaces of the functional elements which are finally executed with an accuracy in the tenth shares of a micrometer, such as an airfoil profile and a wearproof covering nitride of titanium.

These factors, being, certainly, necessary elements of technology, define the additional difficulties connected to the fact that each of the specified surfaces is in different operating conditions and shall save the given configuration in case of action of tension of different value and the direction. At the same time it is necessary to provide the required geometrical accuracy to both each surface, and the 6th mutual orientation of these surfaces among themselves. Therefore one of the most important technological aspects of process of manufacture of precision nodes and constructions is support of stability of their geometrical accuracy at the level which can reach the tenth shares of a micrometer. It is obvious that enhancement and improvement of quality of the manufactured gyro instruments, is directly connected to opportunities and a level of development of the most effective remedies of technological support of process of their manufacture.

But the developed technological methods and the principles of a shaping are applicable only for rather narrow areas connected only to formation of the sphere or a precision finishing of spherical surfaces. Besides the researches stated above were connected to support of accuracy on a manufacturing stage and didn't analyze its saving eventually. It defines need and importance of reviewing of developments and course of micro plastic deformation for a node — processes of creep and a relaxation, in expanded time frames and in more severe conditions, including the operation period [2].

Today high accuracy of a gyroscope and persistence of operating characteristics during the retention period, settings of the instrument in the navigation system and operation are provided in an insufficient level.

The existing technological processes of manufacture of precision details of the gas bearing have insufficiently high level of reproducibility of results regarding support of precision parameters. In case of

manufacture of precision details of the gas bearing there are problems as with receiving precision of level of the tenth shares of a micrometer, and their saving during a retention period, assemblies and operation of the instrument. All this does the task of increase of accuracy and sized stability of precision details and a node of the gas bearing very actual without which solution improving of qualitative characteristics of instruments in general is impossible.

Geometrical accuracy and the measured details are stability of accuracy and tools knots of a gyroscope, development conceptual and applied approaches with use elements the analysis the systems and methods of repetition allowing to estimate and analyze in difficult production processes knots of accuracy at the consecutive interdependent levels are necessary for the solution of problems: material, detail, knot. At each level it is necessary to show and estimate that the comparative value of the possible reasons instability develops criteria for evaluation of their influence and technological methods and economy increase and accuracy means of knot. Here some problems Solutions of maintenance geometrical accuracy details and knots of tools a gyroscope and stability during operation are shown. The first way is increasing micromechanical features of an alloy such as h limit of the macro elasticity determines the level of residual efforts in material. The last one does not allow developing of micro plastic intensity. The second, reduction area of modification residual efforts in ready knot in case operation is close to a limit of level of macro elasticity of material.

The first direction the researches of metals for increase of micromechanical characteristics of an alloy assumes a certain share. At the same time control of micro structural parameters of an alloy is the tool for increase of its sized stability.

The second direction provides reviewing of manufacturing techniques from line items of lowering of level of residual stresses in details, but in too time and saving their form that it is connected to need of the analysis of the entered tension on different operations of technological process and development of the methods reducing the entered tension.

Such approach reflects multi-level nature of research, assumes development of set of the interdependent objective criteria and progressive technical solutions providing controlled nature of technological process of manufacture of details and nodes that will allow to solve a problem of receiving and saving during the long time frame of geometrical accuracy of precision details and nodes of gyro instruments.

Increasing of level of technological support of process of manufacture of precision details and nodes of an age-hardening alloy 40HNYU-VI, on the example of support and flanges of a gas bearing of a two-degree floated type gyroscope, with detection of the progressive technical solutions allowing to provide controlled nature of process of a shaping and saving geometrical accuracy of products at the level of the tenth shares of a micrometer is one of the modern methods of support of accuracy of gyroscopic systems [3].

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