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THE ESSENCE OF THE PROCESS OF VIBRATIONAL FINISHING AND CLEANING, ITS TECHNOLOGICAL CAPABILITIES AND WAYS TO INCREASE EFFICIENCY

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Abstract. *The main provisions of the classification of the vibration processing process depending on the characteristics and composition of the processing medium are given. It is established that vibration processing is a mechanochemical removal of metal particles and its oxides, and plastic deformation of the microroughness of the surface of the part. It was found that vibration processing is related to mechanical dynamic processes, when using chemically active solutions it is related to mechanochemical processes, according to technological purpose to dimensionless processes, according to the type of tool – to processing with free abrasives. It was determined that vibration processing is characterized by the dynamic mechanochemical effect of abrasive medium granules on the treated surface and the acoustic effect of shock waves. It has been established that the features of mechanical and physicochemical phenomena of vibration processing differ in the physical properties of the granules of the medium, the characteristics of the material of the processed parts, the dynamic nature of the process, the composition and properties of the chemically active solution. A classification of defects in the formation of parts, controlled parameters and vibration processing operations is given. The technological capabilities of the processing are presented, these are micro-cutting and surface plastic deformation, the effect of variable accelerations and continuous application of micro-impacts to the surface being processed, which ensures the dynamic nature of the process and creates conditions for strengthening and stabilizing processing. The design of the vibration machines allows the use of various compositions of solid, liquid and mixed compositions of working media. To increase the efficiency of the process, a variable scheme for combining technical solutions of new varieties of the vibration processing process is proposed. It has been established that by combining various combinations of technological and design parameters it is possible to expand the scope of application of the vibration finishing and cleaning process based on the creation and implementation of its varieties.*

Keywords: *vibration finishing and cleaning; process classification; workpieces; classification of shaping defects; combination of technical solutions; area of application of the process; process varieties..*

1. General provisions for the classification of vibration machining processes

Vibration processing, depending on the characteristics and composition of the processing medium, is a mechanical or mechanochemical removal of the smallest particles of metal or its oxides and plastic deformation of microroughness as a result of mutual collisions of the granules of the medium with the processed surface of the parts caused by vibration of the tank in which the processing medium and the processed parts are placed.

In accordance with the accepted classification, vibration processing is related to mechanical processing processes, and when chemically active solutions are introduced into the working environment, it should be classified as a combined process, in particular, as a group of mechanochemical processing processes.

Vibration machining is a dynamic and, by its technological purpose, a dimensionless machining process. By the type of tool used, it is a free abrasive machining process [1].

2. Basic phenomena and features of the vibration processing process

In general, vibration processing is characterized by the following phenomena:

– dynamic impact of the processing environment in the form of multiple collisions of its granules with the surface of the workpiece;

– mechanochemical interaction of the abrasive medium and the material of the part;

– acoustic impact of shock waves.

The features of mechanical and physical-chemical phenomena during vibration processing are as follows:

– physical properties of abrasive granules of the medium;

– characteristics of the material of the parts being processed;

– dynamic process parameters;

– composition, properties and quantity of chemically active solution.

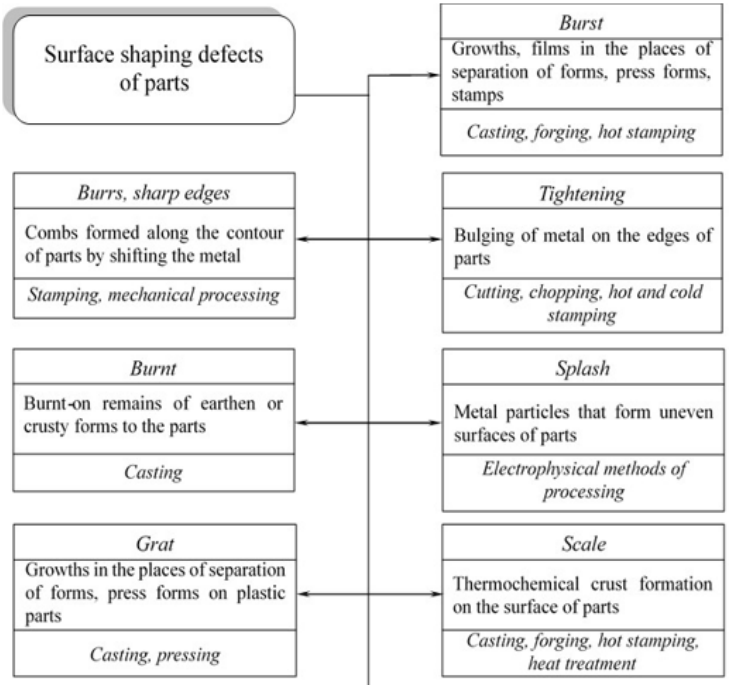
The efficiency of the vibration processing process, assessed by the weight removal of metal from a unit of surface area of the processed part per unit of time, depends on the intensity of mechanical and chemical effects and the ability of the part material to resist the action of these phenomena [2].

3. Classification of defects in the formation of parts, controlledparameters and operations of the vibration processing process

The results achieved when performing various processes of processing a part are determined by the nature of the interaction of these parts with the working environment, as well as the processing modes. The interaction characteristics are considered as a general concept that includes the nature of the movements performed by the workpieces and the working environment and the forces that arise in this process.

Vibration processing and its varieties are considered as a combination of the effects of several types of energy and schemes during technological operations such as casting, pressing, forging, hot and cold stamping, processing on metal-cutting machines, which are accompanied by the formation of defects on the surface of the processed parts, causing deviations in their shape, accuracy and roughness from the specified values. These defects in the production of parts must be removed before assembly operations of the products and their further operation.

For the final processing of parts, defects acquired at various stages of their manufacture are classified from the standpoint of the structure and features of the technological processes for obtaining blanks of these parts (Fig. 1).



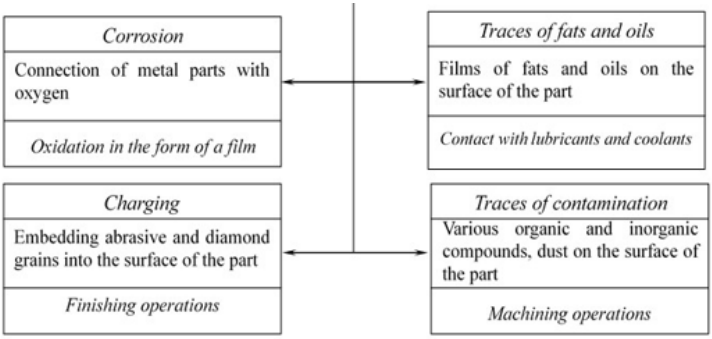


Fig. 1 Classification of surface shaping defects of parts subject to removal by finishing and cleaning treatment

All defects in the formation of the surface of a part in metalworking production are removed by carrying out various finishing and cleaning operations, the classification of which is given below (Fig. 2).

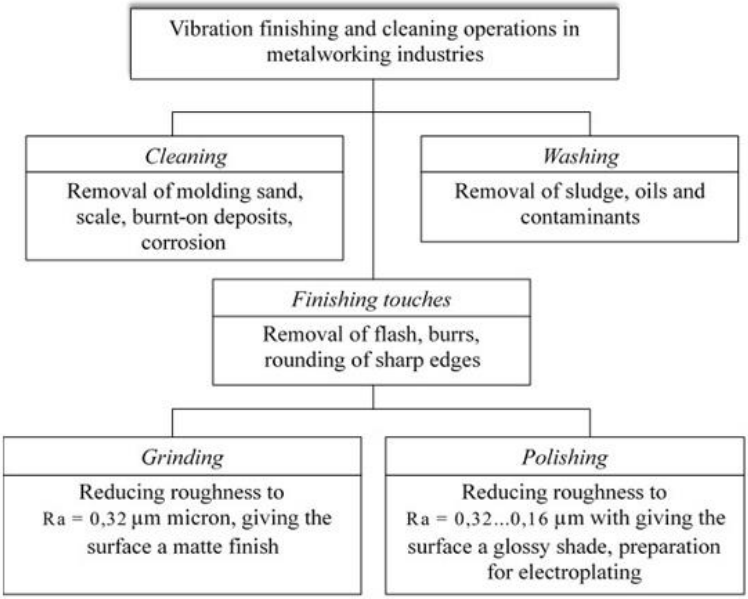


Fig. 2 Classification of vibration finishing and cleaning operations used in metalworking industries

When considering cleaning operations, the controlled parameter of the processing process is the degree of cleanliness of the parts from metallic and non-metallic defects physically and chemically connected to the material of the part. In addition, the effect of the duration of processing on the surface cleanliness is controlled, which is illustrated graphically (Fig. 3) [3].

4. Technological capabilities of the vibration processing process

An examination of the technological capabilities of the vibration processing process shows that they consist of a complex effect of a number of factors on the processed surfaces of parts [4]:

– multiple micro-impacts of the working medium granules, ensuring uniform impact on the surfaces of the parts being processed;

– variable accelerations causing shock wave processes and bending stress in the workpieces;

– chemically active solutions that cause physical and chemical processes;

– intensive movement of the working environment and workpieces.

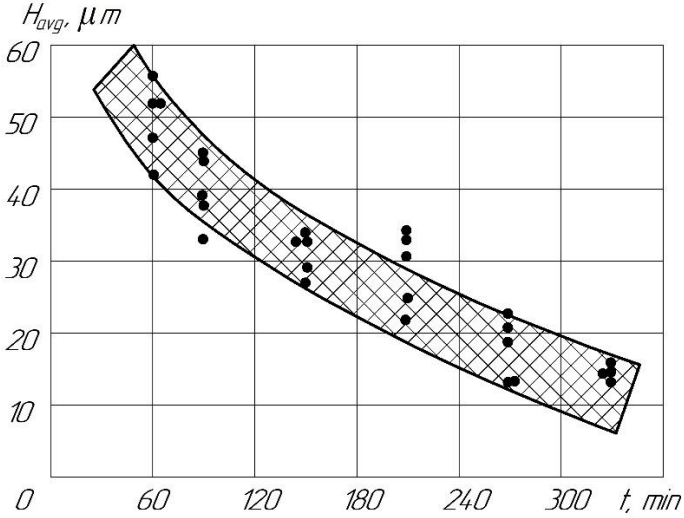


Fig. 3 Effect of processing time on the surface finish of castings

By analyzing the values of each of the listed process factors, we can imagine its technological capabilities, which are as follows:

– Micro cutting and surface plastic deformation are the main elements of the vibration machining process. The absence of a rigid connection between the part and the tool eliminates the possibility of effective and controlled influence on the geometric dimensions and shape of the part. Therefore, the vibration processing process is dimensionless, i.e. does not determine the shape and dimensions of the parts being processed.

– The effect of variable accelerations at different orientations of the workpieces and continuous application of micro-impacts to the workpiece surface ensures the dynamic nature of the process, shock-wave phenomena and the performance of such operations as removal, alignment and creation of optimal residual stresses ensure its stabilization at a certain level. Conditions are created for the implementation of strengthening and stabilizing treatment.

The design of the vibration machines and the long-term vibration processing process allow for the placement and use of various compositions of solid, liquid and mixed compositions of working media, as well as changing their temperature. This creates conditions for both mechanical processing processes and physical-mechanical processes of their combination by introducing powder materials, solutions, suspensions, and electrolytes into the working environment, which intensifies the processing process.

5. Improving the efficiency of the vibration machining process

Consideration of the issue of increasing the efficiency of the vibration processing process made it possible to propose a variable scheme for combining technical solutions for new types of vibration processing processes (Fig. 4) [5].

When implementing process variations, according to the hardware design options of the technological system "tank with working medium - device with workpieces" in the tank of the vibratory machine, an energy effect is formed that creates a general circulation character of the cyclonic movement of granules of the working medium, freely penetrating to all hard-to-reach areas of the surface of the workpiece, which leads to high intensity of processing, the control of which is carried out by choosing rational combinations of the values of the amplitude-frequency parameters of the oscillatory movement of the tank and the device with workpieces, as well as the rotational movement of the spindle and impeller of the vibratory machine.

The workpieces are given additional types of oscillatory and rotary motion by installing them in machine tools, spindles and other devices. By combining various

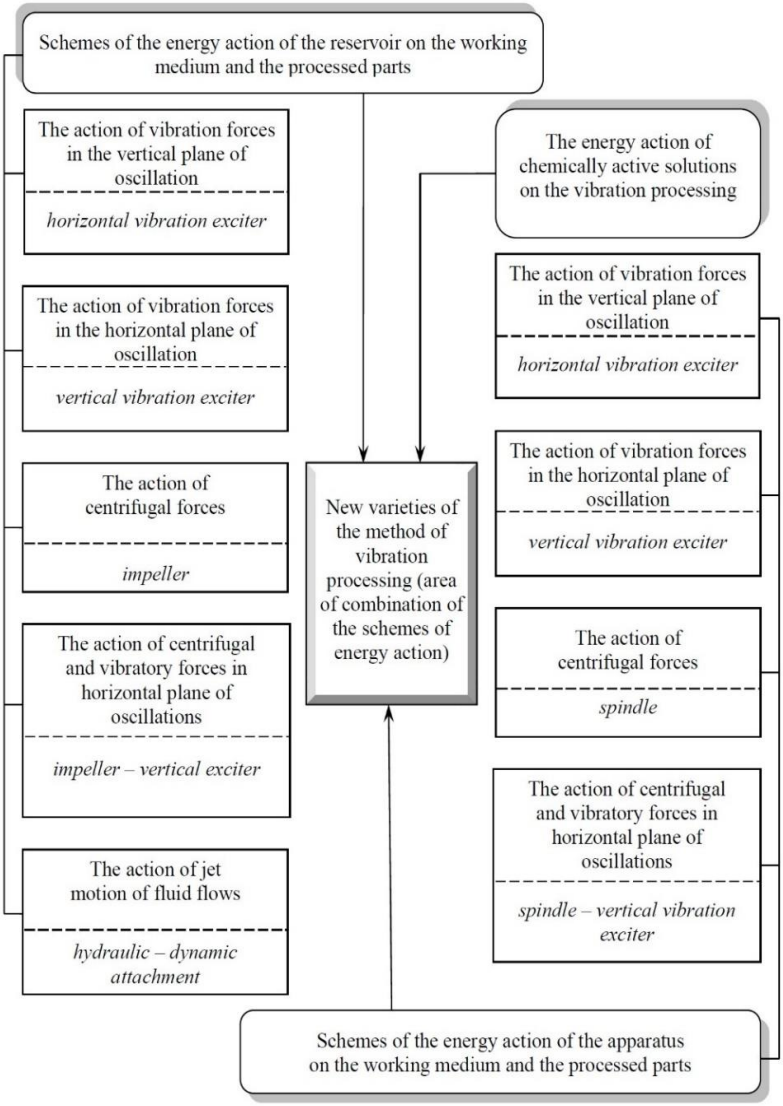


Fig. 4 Variable scheme of combining energy impacts and design elements of technical solutions of new types of vibration processing methods

combinations of technological and design parameters, it is possible to significantly expand the scope of application of the vibration finishing and cleaning process based on the creation and implementation of its new varieties [6].

Of all the problematic, from the point of view of finishing and cleaning processing, nomenclature of parts of drive and distribution mechanisms, as well as parts of the type of body of revolution, such as disks, bushings, coils, pulleys, gear wheels and others, having a symmetrical surface shape and central through holes, which can be used for basing and fixing in devices of working bodies of vibratory machines.

6. Conclusions

1. It has been revealed that the process of vibration processing is a complex of interrelated phenomena involving: microcutting; elastic-plastic deformation; activation of the surface layer of the metal; formation and destruction of secondary structures, repeating with the frequency of the action of the disturbing force.

2. It has been established that chemically active solutions perform the following functions during vibration processing: intensification of the process by chemical action on the processed surfaces of the part; cooling of the part during processing; removal of wear products from the reservoir; prevention of sticking of flat parts.

3. A variable scheme of hardware design of the technological system “tank with working medium – device with workpieces” is proposed, the use of which creates favorable conditions for processing parts with complex-profile surfaces with a free abrasive medium.

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СУТНІСТЬ ПРОЦЕСУ ВІБРАЦІЙНОЇ ОЗДОБЛЮВАЛЬНО-ЗАЧИЩУВАЛЬНОЇ ОБРОБКИ, ЇЇ ТЕХНОЛОГІЧНІ МОЖЛИВОСТІ ТА ШЛЯХИ ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ

Анотація. *Наведено основні положення класифікації процесу вібраційної обробки залежно від характеристик та складу обробного середовища. Встановлено, що вібраційна обробка є механохімічним зніманням частинок металу та його оксидів, та пластичним деформуванням мікронерівностей поверхні деталі. Виявлено, що вібраційна обробка відноситься до механічних динамічних процесів, при використанні хімічно-активних розчинів її відносять до механохімічних процесів, за технологічним призначенням до безрозмірних процесів, за видом інструменту до обробки вільними абразивами. Визначено, що вібраційна обробка характеризується динамічною механохімічною дією гранул абразивного середовища на оброблювану поверхню та акустичним впливом ударних хвиль. Встановлено, що особливості механічних та фізико-хімічних явищ вібраційної обробки відрізняються фізичними властивостями гранул середовища, характеристикою матеріалу оброблюваних деталей, динамічним характером процесу, складом та властивостями хімічно-активного розчину. Дана класифікація дефектів формоутворення деталі, контрольованих параметрів та операцій вібраційної обробки. Представлені технологічні можливості процесу обробки, це мікрорізання та поверхневе пластичне деформування, вплив змінних прискорень та безперервне нанесення мікроударів по оброблюваній поверхні, що забезпечує динамічний характер процесу та створює умови зміцнювальної та стабілізаційної обробки. Конструктивне виконання вібростатів дозволяє застосовувати різні склади твердих, рідких та змішаних складів робочих середовищ. Для підвищення ефективності процесу запропоновано варіативну схему комбінування технічних рішень нових різновидів процесу вібраційної обробки. Встановлено, що комбінуючи різні поєднання технологічних та конструкторських параметрів, можливо розширити область використання процесу вібраційної оздоблювально-зачищувальної обробки на основі створення та впровадження її різновидів.*

Ключові слова: *вібраційна оздоблювально-зачищувальна обробка; класифікація процесу; оброблювані деталі; класифікація дефектів формоутворення; комбінування технічних рішень; область використання процесу.*