# VIBROACOUSTIC SIGNALS IN CUTTING METALS

[1]Fayzimatov Bakhodir Numanovich, [2]Khusanov Yunusali Yuldashalievich, [3]Abduvoxidov Shaxriyor Zikrullo o‘g‘li
Candidate of Technical Sciences, Andijan Machine-Building Institute[1], Doctor of Philosophy in Technical Sciences (PhD) Fergana Polytechnic Institute[2], Master's Andijan Machine-Building Institute[3]

---

## ANNOTATION

This article provides information on the analysis of the process of generation of vibroacoustic signals during cutting.

***Keywords: vibroacoustic signals, cutter erosion, cutting signal amplitude, machining, plastic deformation.***

## INTRODUCTION

The vibroacoustic method for monitoring the status of the cutting tool in digital program-controlled (CNC) machines is manifested in the correct selection of the operating frequency range, i.e. the change in signal amplitude from the cutting of the cutting tool. The theoretical possibilities of such types of processing are still problematic, and the entire frequency range is limited by the capabilities of modern vibration sensors, which are not sufficiently intelligent and equipped with self-control means. A number of experiments were performed on conventional lathes and CNC machines to determine the information frequency range in the sound range. In studies, the depth of cut, the value of t thrusts, and the number of rotations S and n vary over a wide range.

Materials made of different metals with different physical and mechanical properties were used. For example: steel, brass, duralumin were made by CNC type machines using T15K6 cutter. The cutter has the following geometric dimensions: length 120 mm, width 10mm, thickness 12mm, cutting angles a = 12 °, g = 18 °, ph = 60 °, ph1 = 15 °. Amplitude-frequency characteristics (VAC) of machine oscillations in the absence of sound cut-off mode when the CNC is switched on in the same sound-cutting modes on digitally controlled machines (Fig. 1), the cutter touching the machined surface, (Fig. 2) cutting mode, Figure 3). In the ChPU machine, the material to be machined is steel, spindle speed v = 200 rpm, thrust value S = 0.1 mm / rpm, cutting depth t = 0-0.5 mm. The signal of the torque (VAC) of the cutter on the rotating workpiece is shown in Figure 2

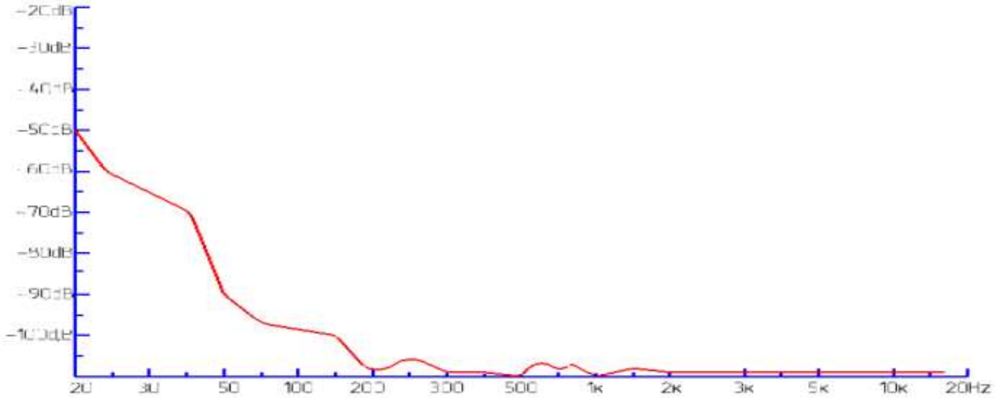


Figure 1. (oscillation of the axis of the machine itself) The number of revolutions of the spindle - 200 rpm

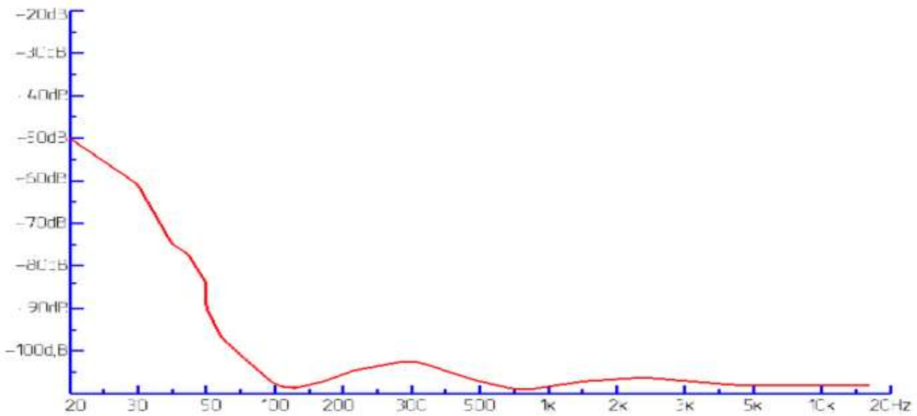

Figure 2. VAC of the signal received from the cutter in sensor mode. Material steel, cutting speed on the spindle -200 rpm, cutting depth -0 µm (touch), n-0.1mm / rpm

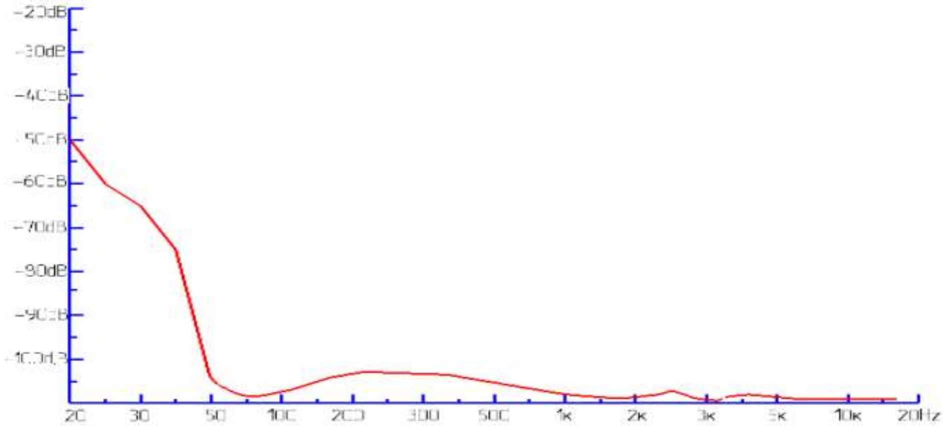

Figure 3 VAC of the signal received from the cutter in sensor mode. Material steel, cutting speed on the spindle -200 rpm, cutting depth -10 µm (touch), n-0.1mm / rpm

## REFERENCES

At present, various methods of assessing the dynamics of complex vibroacoustic processes are used in vibrodiagnostics. For vibroacoustic analysis of the cutting process, it is advisable to use the following methods: PIK factor method, direct spectrum method, envelope spectrum method. PIK factor method. In this method, the PIK factor method monitors the change in the ratio of the maximum amplitude of the oscillation signal in the selected frequency range to its average value, e.g., 200-300 Gts, 2-3 kHz range (Figure 4).

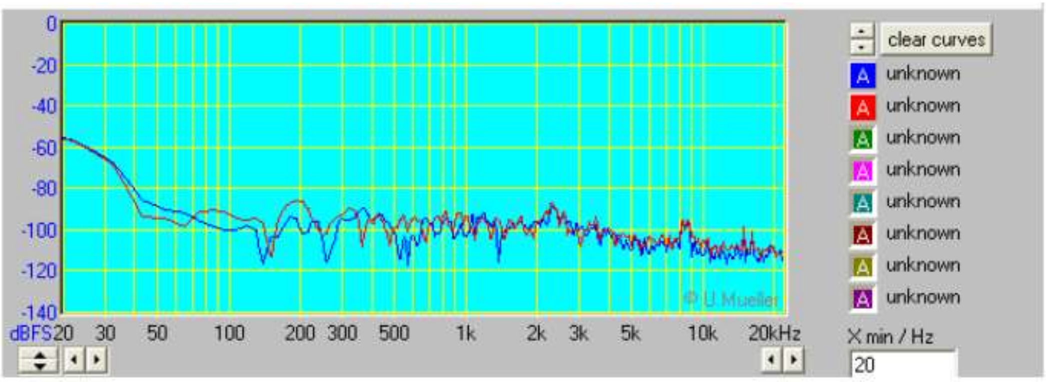


Figure 4. Occurred during cutting with a sharp-edged cutter (VAS)

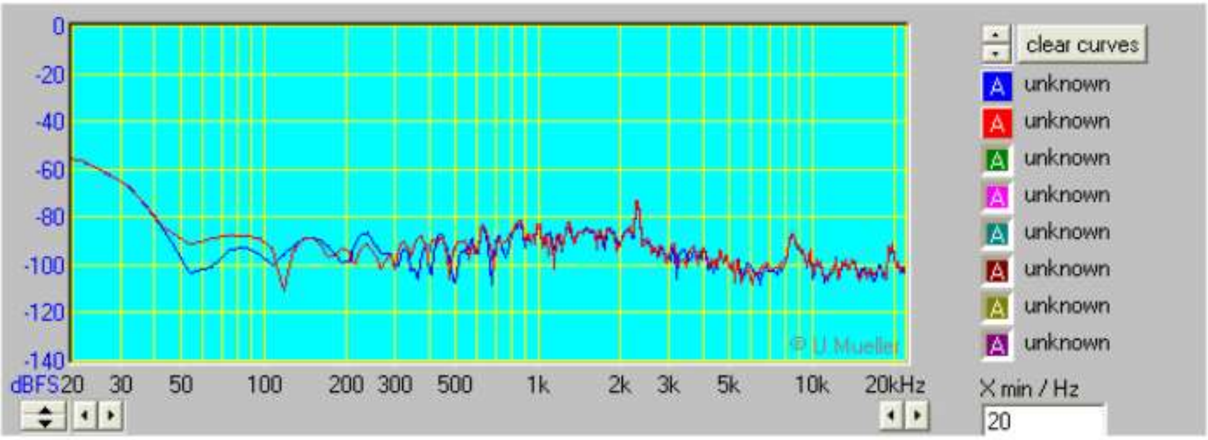


Figure 5. Cutter cutting time interval (VAS)

The main advantage of the method is to determine the beginning of the destruction of the cutting tip and to observe the subsequent process of its destruction. The main disadvantages are the weak noise immunity of this method and the need for constant measurements during the cutting process. When the PIK factor changes in the selected frequency range, the ChPU sends a signal to the control unit to use the vibroacoustic touch control and measure the dimensional deflection for the cutter.

Direct spectral method.This method can be analyzed in Figure 5 not only in terms of the ratio of amplitude and energy characteristics, but also in terms of the frequency of amplitude occurrence. This principle is applied in the direct spectrum method. The vibrating signal is analyzed by a high-band spectrum analyzer, and the occurrence and development of cut-off tip defects are determined by the frequency composition of the spectrum.

The method has two main advantages:

- sufficiently high noise level (it is unlikely that there are sources in the cutting zone that generate vibrations at the same exact frequencies as the cutting tip defects);

- the information content of the method works much better than the PIK factor method. In addition to the two main advantages of the method, it also has two disadvantages:

Method 1 requires a small-band spectrum analyzer;

Method 2 is insensitive to small defects for the cutter. This is because the wear for the cutter has little effect on the vibroacoustic image of the cut. Only with the cutting edges of the cutter having sufficiently strong defects, the useful vibroacoustic signal differs significantly from the general noise part of the spectrum. When using this method, in one of the changes that occurs after detection, the signal is sent to vibroacoustic control by touch to determine the dimensional wear of the instrument.

The spectral method is envelope.The high frequency part of this signal changes its amplitude over time, it is modulated by the low frequency signal. This modulation may include information about the position of the cutting edge of the cutter. The separation and processing of this information forms the basis of this method. This method gives the best results when analyzing the modulation of a non-broadband signal from an accelerometer, but first by performing band filtering of the vibration signal in the operating range and analyzing the modulation of this signal.

To do this, a filtered signal is detected, ie. the modulating signal is separated (it is called "envelope" and the signal is transmitted to a small-range spectrum analyzer) and we get a modulating signal spectrum or envelope spectrum that heats us up. The application of this method also involves the transmission of a signal to the ChPU machine for vibroacoustic control by vibration, and then measuring the dimensional erosion of the cutting edge.

It is advisable to use the PIK factor method to analyze the condition of the cutting edge It allows you to track from the beginning to the end of its decomposition. It is expensive hardware and does not require any expert opinion.

**RESULTS**

Touch control has a special place among the methods of vibroacoustic control of the cutting tool state. This should be more related to operational or postoperative monitoring of the condition of the cutting tool, which is characterized by high-precision control (ChPU Device phase).

To monitor the condition of the cutting signal sound instrument described above, an accurate measurement of the dimensional erosion of the instrument controlled by the signal of the vibroacoustic device is performed. It is advisable to store the vibroacoustic control algorithm with the vibration method of the cutting tool state in the memory of the ChPU machine as a software package.

The program can have different features for machining parts: cutting time, tool life, counting the number of finished products, cutting zone temperature, etc., but the most convenient and accurate is active vibroacoustic monitoring of the cutting tool status with a signal from the device. In this signal the machining process of the part is completed and the wear of the cutter is controlled by simultaneous counting until the time of touching by the touch method.

- use the method of touching the main surface;
- use the method of touching the surface of the blank with a suitable cutter.

In the first case, the steps are calculated from the initial control position of the tool to the base surface formed and mounted on the machine spindle. The touch is done with the same tool, first sharp, then worn. The dimensional wear of the tool is determined by the headlight between the steps of the sharp and worn wear on the base surface. The disadvantage of the first method is related to the need to create a rotating surface of the base fixed to the machine spindle and the need to control its position, which requires additional time. In the second case, to determine the wear of the tool, the cutting is stopped, the cutter operated by counting the steps is moved to the initial position, then the reference cutter is brought to the control position, the number of steps on the surface of the machined part is taken into account. After that, the number of running and reference cutter steps is compared and the wear of the tool is determined. If the wear is not very significant, the machining of the part continues from the stop and the difference in steps is produced by the running engine. If the wear is more than allowed, an alarm is given to replace the instrument.

According to the latest data, the share of mechanical processing accounts for 60% of the time and tools spent on the manufacture of the product. Metalworking by cutting has been and continues to be the primary method of ensuring the accuracy and quality of machining of parts. Significant growth of machine-building products is achieved by increasing the productivity of labor in mechanical processing.

The time spent on each process in detail processing consists of two parts: a) the main technological (or machine) time; b) auxiliary time.

The increase in labor productivity is achieved by reducing the auxiliary and main technological (machine) time. The reduction of auxiliary time is achieved, firstly, by automating the working bodies of the machine, secondly, by using fast-moving machine tools, and thirdly, by improving the machining process.

When choosing the parameters of the cutting process, first of all, the value of information such as strength, power, temperature is given. Next, we present the results of the research, which are used to easily and quickly evaluate the processing of metals from these parameters. In this regard, we focus on the vibroacoustic signal (VAC), the cutting zone.

In metal cutting theory, the selection of vibroacoustic signal as information parameters, determination of the status of the signal cutting tool and analysis of methods and means of diagnosing the cutting process in general, as well as on the basis of key factors.

Thus, the occurrence of abrasion of the cutting tool is clearly reflected in the friction, plastic deformation, adhesion and diffusion phenomena on the cutting surfaces, on the surfaces of the cutting tool and parts, as well as in the cutting process of the tool material in the cutting zone. In this case, the transition from a state with a high energy value of elementary particles to a lower energy value and the introduction of a portion of the excess energy occurs. The change in energy in the cutting tool leads to the formation of elastic waves and tension waves, because the friction falling on the front surface of the tool causes the formation of cracks, dislocation motion, and changes - structural changes, the contact part of the machined tool and causes the cutting tool to corrode. Therefore, the corrosion resistance of the tool material depends on the duration of these processes.

When cutting metals, very small (micro) cracks appear on the contact surfaces, which primarily leads to the formation of vibroacoustic (VAS) signals.

During cutting, the amplitude of the vibration signal reaches its maximum value and then changes, the characteristic is that in the initial period of the cutting process the changes in the amplitude of the vibroacoustic signal (VAS) are intensively delayed and after a while reach a stable level and a small increase in signal amplitude is observed. The results of experiments on various tools and working metals show that the stabilization time of the vibroacoustic signal (VAC) corresponds to the time of decommissioning of cutting tools, ie the time of purchase of a new cutting tool.

At the same time, the amplitude of the initial, vibroacoustic signal (VAC) of the cutting tool and the material to be processed is determined. The value and amount of intervals determined during this time period will depend on the amplitude. The wear of the cutting tool changes at each time interval end interval. The first hard alloy plate is then cut at the edge surface and the first time intervals, and the second surface is cut during the first flow and second time intervals during the cutting cycle. Thus, the end edge of the cutter is used to cut for a period of time equal to the stabilization time of the vibroacoustic signal (VAC) amplitude for a given processing condition during the entire operation.

Figures 6 and 7 show the erosion of the organ surface of the cutting tool when machining alloy steel 30XGSA with a T5K6 cutter and steel 45 with a T5K10 cutter.

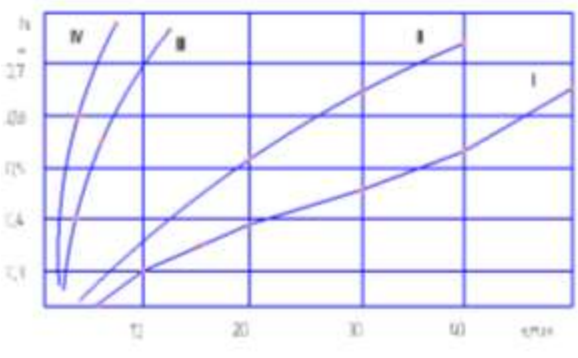

Figure 6 - wear of the cutting tool during cutting with alloy steel 30XGSA to T5K6 cutter; S = 0.2mm /rev, t = 0.5mm, I) V = 1.92m /s, II) V = 2.4m /s, III) V = 4.3m /s, IV) V = 4.3m /s.

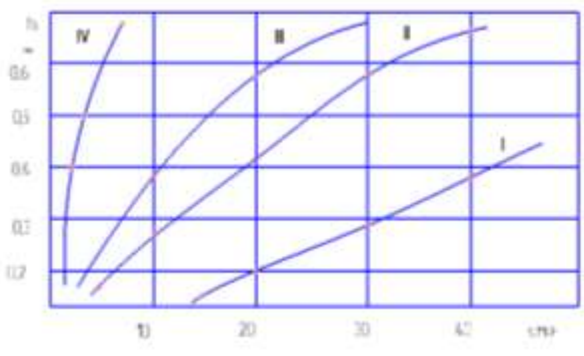

Figure 7 shows the wear of the cutting tool during cutting of steel 45 to T15K10 cutter; S = 0.1mm /rev, t = 0.5mm, I) V = 2m /s, II) V = 2.7m /s, III) V = 3.6m /s, IV) 4.9m /s.

The next step in determining the posterior parameters is to determine the intensity of the vibroacoustic signal (VAC) change during the initial period of the cutting process, usually depending on the wear of the cutting tools in the cutting area.

In our graphs above, a combined analysis of the abrasion of the cutting abob and their abrasion lines, the change in amplitude of the vibroacoustic signal (VAS) over time, shows that certain similarities exist for these correlations, i.e. comes: a slight change in the normal eating area i.e. growth; a high level of distortion is a significant increase in the amplitude of the measured signal. From the above analysis, we conclude that the process of vibroacoustic signal generation during cutting can be controlled, ie diagnosed.

## CONCLUSION

The analysis of the methods of monitoring the condition of the cutting tool on ChPU machines has shown that the most suitable method for practical application in industrial conditions is the vibroacoustic control method. Application of the method allows the use of high-precision and vibroacoustic sensor (VAS) to control all instruments of the machine.

## REFERENCES


1. Махмудов К.Г., Остафьев В.А., Мирзаев А.А. Автоматизированные методы определения обративаемости металлов. Киев.1995-91л.
2. Файзиматов Б.Н., Мирзаев А.А. Материалларни кесиб ишлаш асослари Фаргона-техника.2003-195л .
3. Mamadjanov, A. M., Yusupov, S. M., & Sadirov, S. (2021). ADVANTAGES AND THE FUTURE OF CNC MACHINES. Scientific progress, 2(1), 1638-1647.
4. Mamadjanov, A. M., & Sadirov, S. (2021). ANALYSIS OF DESIGN ERRORS IN MECHANICAL ENGINEERING. Scientific progress, 2(1), 1648-1654.
5. Улуғхожаев, Р. С. (2021). ИШЛОВ БЕРИЛАЁТГАН ДЕТАЛНИНГ АНИҚЛИГИНИ ОШИРИШ УЧУН МЕТАЛ ҚИРҚИШ ДАСТГОХЛАРИНИ БОШҚАРИШДА ВИБРОАКУСТИК СИГНАЛЛАРДАН ФОЙДАЛАНИШ. Scientific progress, 2(6), 1241-1247.
6. Fayzimatov S. N., Xusanov Y. Y., Valixonov D. A. Optimization Conditions Of Drilling Polymeric Composite Materials //The American Journal of Engineering and Technology. – 2021. – Т. 3. – С. 22-30.
7. Fayzimatov B. N., Numanovich F. S., Khusanov Y. Y. Perspective drilling methods, non-technological holees in polymeric composite materials //International Journal of Engineering Research and Technology. – 2021. – Т. 13. – №. 12. – С. 4823-4831.
8. Fayzimatov B. N., Xusanov Y. Y. PROBLEMS OF GLASS SURFACE QUALITY FORMATION FOR MECHANICAL PROCESSING //Scientific-technical journal. – 2018. – Т. 22. – №. 2. – С. 35-39.
9. Xusanov Y. Y., Valixonov D. A. O. G. L. POLIMER KOMPOZITSION MATERIALLARDAN TAYYORLANGAN DETALLARNI PARMALASHNI ASOSIY KO ‘RINISHLARI //Scientific progress. – 2021. – Т. 1. – №. 6. – С. 1169-1174.
10. Хусанов Ю. Ю. Мамасидиков БЭУ ПОЛИМЕР КОМПОЗИТ МАТЕРИАЛЛАРНИ ПРАМАЛАШДА КИРИНДИ^ ОСИЛ БУЛИШ ЖАРАЁНИ ТАДЖИК КИЛИШ //Scientific progress. – 2021. – Т. 2. – №. 1. – С. 95-104.

11. Хусанов Ю. Ю., Таштанов Х. Н. Ў., Сатторов А. М. МАШИНА ДЕТАЛЛАРНИ ПАРМАЛАБ ИШЛОВ БЕРИЛАДИГАН НОТЕХНОЛОГИК ЮЗАЛАР ТУРЛАРИ //Scientific progress. – 2021. – Т. 2. – №. 1. – С. 1322-1332.
12. Хусанов Ю. Ю., Нематжонов Х. А. Ў. НОТЕХНОЛОГИК ЮЗАЛАРНИ ПАРМАЛАБ ИШЛОВ БЕРИШ ТЕХНОЛОГИЯСИНИНГ ТАҲЛИЛИ //Scientific progress. – 2021. – Т. 2. – №. 6. – С. 1160-1168.
13. Хусанов Ю. Ю., Тўхтасинов Р. Д. Ў. ПОЛИМЕР КОМПОЗИТ МАТЕРИАЛЛАРГА МЕХАНИК ИШЛОВ БЕРИШНИНГ ЗАРУРАТИ //Scientific progress. – 2021. – Т. 2. – №. 2. – С. 866-869.
14. Файзиматов Ш. Н., Анвархужаев Т. Б. У., Рахмонов С. Ш. У. СОВЕРШЕНСТВОВАНИЕ ТЕХНОЛОГИИ БОРИРОВАНИЕ СТАЛЕЙ ИЗ ОБМАЗОК ДЛЯ ПОВЫШЕНИЯ ЖАРОСТОЙКОСТИ И ИЗНОСОСТОЙКОСТИ //Scientific progress. – 2021. – Т. 2. – №. 1. – С. 1455-1460.
15. Файзиматов Б. Н., Мирзаев М. А. Ў. КЕСУВЧИ АСБОБНИНГ КЕСУВЧИ КИСМИНИ ЕЙИЛИШИНИ ВИБРОАКУСТИК УСУЛ БИЛАН АНИКЛАШ //Scientific progress. – 2021. – Т. 2. – №. 2. – С. 794-801.
16. Васильков Д. В., Кочина Т. Б., Файзиматов Б. Н. ОЦЕНКА ПРЕДЕЛЬНЫХ ВОЗМОЖНОСТЕЙ МЕТАЛЛОРЕЖУЩИХ СТАНКОВ ПРИ ИЗГОТОВЛЕНИИ И РЕМОНТЕ НЕФТЯНОГО ОБОРУДОВАНИЯ //Ответственный редактор: Погонышев ДА, канд. биол. наук, проректор по научной работе, ФГБОУ ВО «Нижневартовский государственный университет» Редакционная коллегия: Малышева НН, канд. техн. наук, Нижневартовский государственный университет Мостовенко ЛВ, канд. техн. наук, Нижневартовский государственный университет. – 2021. – С. 13.
17. Абдурахмонов С. М., Кулдашов О. Х., Файзиматов Б. Н. Система для обеспечения орнитологической безопасности в аэропортах гражданской авиации //Безопасность труда в промышленности. – 2020. – №. 10. – С. 61-64.
18. Файзиматов Б. Н. и др. ПРИМЕНЕНИЕ КЛАССИФИКАТОРОВ ISO ДЛЯ ОПРЕДЕЛЕНИЯ УДЕЛЬНОЙ СИЛЫ РЕЗАНИЯ //Культура, наука, образование: проблемы и перспективы. – 2019. – С. 691-696.
19. Файзиматов Ш. Н. и др. КИЧИК ДИАМЕТРГА ЭГА БЎЛГАН ЧУҚУР ТЕШИКЛАРНИ ДОРНАЛАР ЁРДАМИДА ИШЛОВ БЕРИШДА ЮЗА АНИҚЛИГИНИ ОШИРИШ //Science and Education. – 2021. – Т. 2. – №. 3. – С. 181-187.
20. Xusanov Y. Y. et al. AVTOMOBIL OYNALARGA MEXANIK ISHLOV BERISH JARAYONLARIGA MOYLASH SOVUTISH TEXNOLOGIK VOSITASINING TA’SIRI //Scientific progress. – 2021. – Т. 2. – №. 6. – С. 1546-1555.