

Integrated Development Of Noise-Dust Woodworking Machines At The Design Stage

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Abstract. The article deals the problem of creating of integrated security systems from the effects of hazardous and harmful factors of woodworking machinery on the design stage. Proposed the machine device design, which provides noise-dust protection of the operator fulfill the criterion of maximum permissible levels of noise and dust concentrations.

Introduction

Model woodworking machines are widespread and intensively exploited not only in woodworking industry, but in machine-building enterprises too, in particular, furniture shops and foundry areas. Existing modeling tools have technical characteristics, such as precision machining, performance, the reliability of the relevant international standards rigs, but for security duty have poor performance, because creating a working zone operators increased noise levels and concentrations of dustiness, much higher than health standards. Therefore the problem of noise and reduce dustiness model woodworking machines станков is relevant for mechanical engineering and has a great scientific and technical and socio-economic importance ^{*}.

Experimental studies of noise and vibration model machines

Experimental studies of noise spectra and model machines vibration performed under conditions foundry model areas JSC " Rostvertol " and LTD PC NEVZ. Measuring levels of vibration and noise were carried with acoustic meter "Ecophysics".

Research of formation regularities of noise spectra and model machines vibration conducted idling and cutting in various wood species and under typical processing conditions. When measuring noise levels microphone installed at the operator's workplace. When measuring vibrations piezosensor with a magnet fastened to the basic elements of machine tools, and to the blanks stucked with special mastic. It should be noted, that through measuring octave vibration levels fixed values not in normability workplace particle frequency, but in the particle frequency 31.5 - 8000 Hz.

Comparison of noise and vibration spectra allows qualitatively assess contribution of the individual sources into forming sound field in the working zone and identify dominant sources of noise. Idling at maximum rotation speeds sound pressure levels already exceed the maximum allowable value (fig.1).



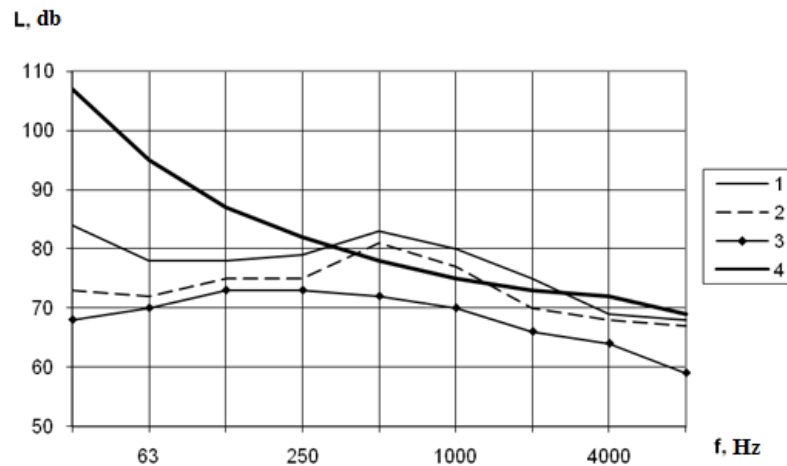


Figure 1 – The spectra of noise in the working area medium model machine idling: 1 - at rotation speed 6000 rpm; 2 - at rotation speed 4500 rpm; 3 - at rotation speed 1500 rpm; 4 - limit spectrum.

At maximum rotation speed 4500 и 6000 rpm sound pressure levels of the machine already exceed the maximum allowable value. For example, at rotation speed 4500 rpm sound pressure levels exceed the maximum permissible in the fifth and sixth octaves with center frequencies 500 и 1000 Hz (respectively) for 3-4 dB. By increasing rotation speed to 6000 rpm excess of sound pressure levels over the maximum admissible is 5dB in the fifth octave with center frequencies 500 Hz, 4 dB in the sixth octave with center frequencies 1000 Hz, 2 dB in the seventh octave with center frequencies 2000 Hz.

When cutting processing noise spectra in the working area changes significantly. In the noise spectra dominant medium and (especially) high-frequency part of the spectrum. For example, for light model machine most intensive components of noise spectra are located in the fifth to tenth octaves (fig.2). Excess of sound pressure levels observed at a spindle rotation speed 3000 rpm and amounts 2-5 dB (processing pine) in the frequency range 1000-8000 Hz. Increasing spindle rotation speed, the intensity of the sound emitting increases too.

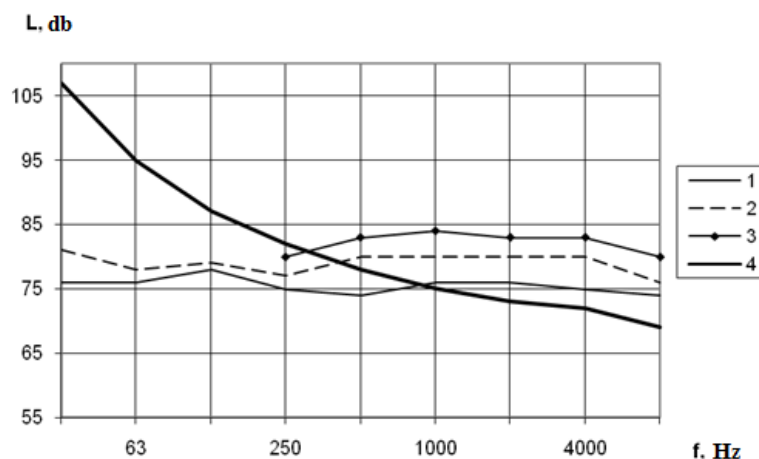


Figure 2 – The spectra of light model machine noise: 1 - processing pine (n=3000 rpm); 2 - processing pine (n=6000 rpm); 3 - processing oak (n=6000 rpm); 4 - limit spectrum.

Expands the active range of the spectrum, which has excess of sound pressure levels over the maximum allowable values. In particular, exceeding noise levels by processing pine is from 2 to 8 dB in the frequency range 500-8000 Hz. When processing hardwood sound pressure levels increasing. For example, when processing oak blanks ($n=6000$ rpm) sound pressure levels in comparison with when processing pine blanks increasing by 3-4 dB, which coincides accurately with theoretical data (estimated value of 4 dB). Excess of sound pressure levels over the maximum permissible amounts of 3-10 dB. It should be noted the nature of identity of noise spectrum for processing different types of wood. Similar results obtained on average model machine FMS. Increasing sound pressure levels in comparison with a light model machine is generally about 2-3 dB in the mid-part of the spectrum 500-1000 Hz it could be assumed, that this fact is explained by increasing cutting power (the theoretical value of 3.2 dB). Increasing sound pressure levels over the maximum allowable values reaches 8-11 dB in medium- and high-frequency part of the spectrum 500-8000 Hz.

To clarify the contribution of noise sources forming a sound field in model machines working zone the measurements of vibration speed on the supporting elements of the system and processing blanks were provided [1].

The highest levels of vibration speed were fixed on buildings spindle headstocks. The levels of vibration speed of the motor body at low frequencies (unto 250 Hz) 8-15 dB are lower, then of body headstock. However directly in medium and high frequency part of the spectrum 500-8000 Hz levels of vibration speed of the motor body are practically the same then of the body headstock. Vibration spectra of frame, table and, especially, blanks,

are pronounced low-frequency character. The main sources, determining the excess of sound pressure levels over the maximum allowable values in the fifth-sixth octaves are: body headstock and cutting tool, firstly, and so the main drive motor.

These data are the foundation to develop technical solutions to ensure sanitary standards noise in the working area of model tools.

Experimental research of model machines dustiness and CRC efficiency

Disperse composition of dust we investigated by sieve analysis and microscopy by standard methods using apparatus for particle size distribution research, including standard set of sieves, vibration system and body with electrical enclosure, and MIN-8 microscope. As a result of preliminary investigations established, that the particle size distribution of all used in the experiments kinds of dust material obeys a log-normal distribution. Fig.3 shows dependence between frequency speed of model machine and size of resulting from processing materials of wood dust particles.

From the obtained data we can conclude, that wood dust and sample taken for analysis is coarsely and has property of polydispersity. Considering, that considered wood dust is coarse, advantage may be given to inertial cyclone duct-collectors, rather than textile filters.

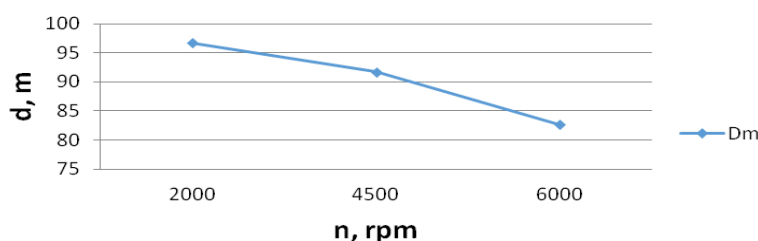


Figure 3 – The dependence of the average wood dust median diameter from the operation mode of model woodworking machine

Besides, increasing wood processing speed on model machines at high rotation speed reduces the average median particle size and decreases capture efficiency of conventional cylindrical cyclones (lower then 92.4%).

Therefore the choice of cleaning vehicles is based on the use of cyclones with advanced conical part and adjustable design parameters for maximum efficiency. CRC, due to the conical profile, uses increased centrifugal force, acting on a dust particle, and the ability to control the immersion depth of the exhaust pipe into cyclone body reduces dust removal by secondary eddy currents of air. Regulation of relations between the volume of working part of the CRC and hopper allows to capture dust of different density with more efficiency [2,3].

Experimental data led to the conclusion, that the taken dust samples are coarse disperse, as well as polydisperse. Further, fixed times, when released a blowout of bulk material from the outlet of cyclone with the same meaning of feed air flow $Q = 25 \text{ m}^3/\text{h}$ ($V = 4.5 \text{ m/s}$). Then was measured the mass of sawdust in the hopper using exact electronic scales and dust cleaning rate was calculated:

$$\eta = \frac{m_{\text{ex}}}{m_{\text{en}}} \cdot 100\%, \quad (1)$$

where m_{ex} - mass of dust after treatment, g; m_{en} - mass of dust before treatment, g.

Research of the efficiency of wood dust collecting were made for different amounts of hoppers from 5 l to 60 l in the particle frequency 40-315 micrometer at a rate of $27 \text{ m}^3/\text{h}$. The efficiency of dust cleaning is higher in the conical cyclone in contrast with cylindrical cyclones and increases in the case of increasing the ratio of the volume of the hopper to the working volume of the cyclone. At the fig. 4 shown efficiency dust collecting of wood dust with conical cyclone depending on its disperse composition, competition of hopper volume to the working volume of the cyclone with optimum ratio of the outlet pipe height to the height of the cyclone $H_p/H_c = 0.6$. Ratio of hopper volume the working volume of the cyclone changed in the course of research and respectively were equal: for hopper capacity of 19 l: $V_h/V_{\text{cc}} = 0.7$; for 30 l: $V_h/V_{\text{cc}} = 1.11$, for 60 l: $V_h/V_{\text{cc}} = 2.22$. As can be seen from the experiments, dust cleaning efficiency higher for the hopper volume of 60 l and ratio $V_h/V_{\text{cc}} = 2.22$.

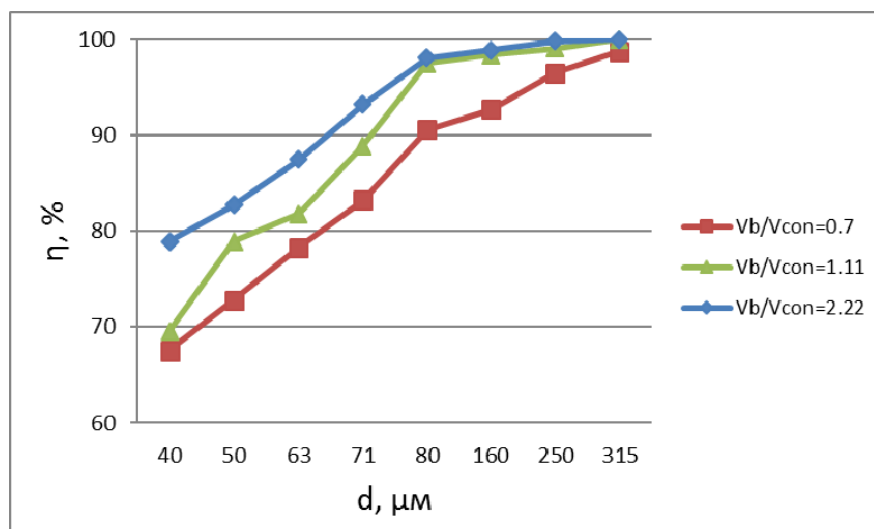


Figure 4 – Dust collecting efficiency of wood dust with conical cyclone depending on the dispersed composition, attitude of hopper volume to the working volume of cyclone with optimum ratio $H_p/H_c = 0.6$

Experimental studies of the impact of exhaust pipe immersion depth on dust collection efficiency by cyclones with a hopper volume of 30 l in the particle frequency of wood dust from 40 to 315 micrometer (fig. 5,6).

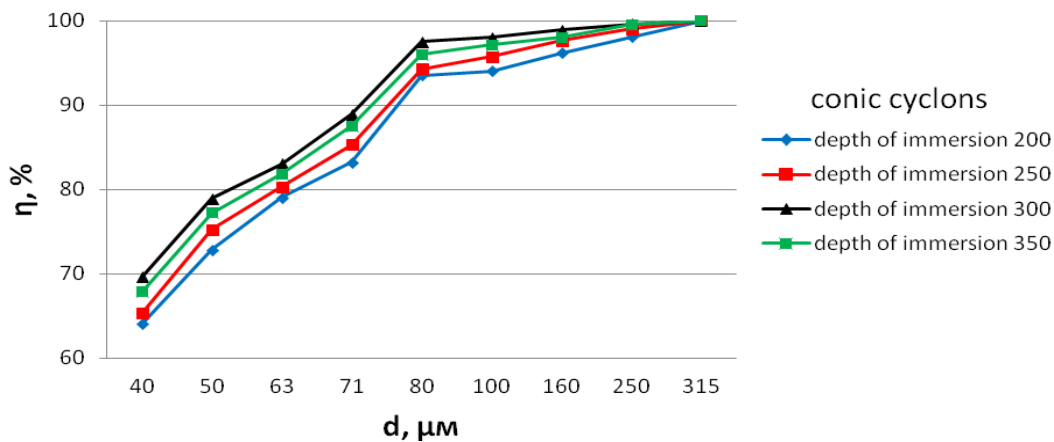


Figure 5 – Dust collecting efficiency of wood dust with conical cyclone depending on the pipe immersion depth of exhaust pipe

From the results of experimental studies it can be made the following conclusions:

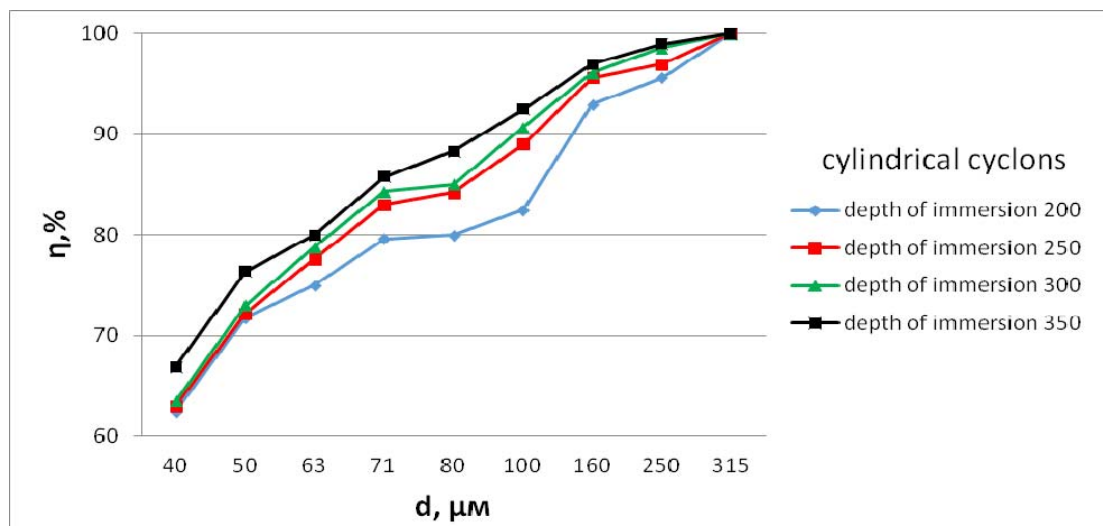


Figure 6 – Dust collecting efficiency of wood dust with cylindrical cyclone depending on the pipe immersion depth of exhaust pipe.

1. With increasing depth of immersion exhaust pipe, at the same values of input speeds of dusty air, dust collection efficiency values of the conical device is much higher than that of cylindrical, most clearly seen this effect at speeds 15-20 m/s.

2. When the immersion depth of the outlet pipe is $h=300$ mm the resistance of the conical cyclone unit takes its maximum value, and dust collection efficiency reaches its maximum value 97-99 %. Conversely, with a further increase of the outlet pipe immersion depth $h=350$ mm the efficiency of the conical cyclone falls.

3. Cylindrical cyclone has maximum resistance at a depth of immersion of exhaust pipe to $h=350$ mm. At this depth experimentally established the greatest efficiency of dust collecting too, which, however, much lower, than the same for conical device (88-92%).

It was established, that the construction of dust collectors of non-cylindrical shape (ball cyclone or a cyclone with a reverse cone (CRC)) with adjustable geometric parameters enable carry out the cleaning dust-air flow process more effective in comparison with the conventional cylindrical

cyclones. Have been founded the optimal attitude of volumes of the working part of the CRC and the hopper, and so attitude of immersion depth of the exhaust pipe to the height of the working part of the machine, in which the dust cleaning efficiency increases to 99 % [3].

Design of noise-dust protection system for woodworking machines.

Below there is the structure of comprehensive protection of operators from the noise and dust impacts (fig.7) [4-10]. The dominant role in the formation of noise spectra in the working zone of the cutting tool sound emitting of the model machines at high frequencies and headstock body at medium frequencies allows to restrict with the noise protection system only the cutting zone.

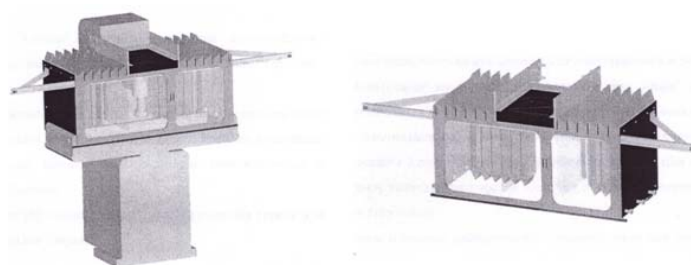


Figure 7 – Noise protective fencing and aspiration cover wood (model) machines

Processing zones protections have a sufficiently high sealability, which increases the concentration of dust under protective device. Therefore, based on the concentration of dust in the cutting zone, calculated concentration of dust under enclosing construction and compared with the experimental values.

Installation of cutting area sound dampening enclosure of light and medium model machines and acoustic screens of medium machines engines provided performance of sanitary norms of noise in the operator's work places. The use of this air purification system from dust reduced the concentration of wood dust in the working zone to $3.5-4 \text{ mg/m}^3$, which is $2-2.5 \text{ mg/m}^3$ lower than maximum allowable concentration.

Conclusions

Analysis of working conditions of operator's work places of model milling machines showed, that disparity sanitary conditions observed for only two dangerous and harmful production factors – dust and noise. The dust concentration exceeds the maximum permissible concentration 6 times, and the sound levels of maximum permissible limit – to 15 dBA.

Experimental studies of vibration and noise spectra, conducted in conditions of foundry model areas revealed the dominating in in excess of sanitary norms noise sources and in fact determined the choice of maximum permissible sound pressure level execution methods.

Developed the construction of noise-dust protection system for model machines. Calculating of design parameters produced by the criterion of performing of maximum permissible levels of noise and dust concentrations.

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