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# THE NOISE ANALYSIS OF THE TECHNOLOGICAL AGGREGATE POWERED BY LIQUID FUEL

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The paper presents the results of noise emissions tests from the technological aggregate - the furnace for joining the cutting elements which is powered by liquid fuel. The article shows the research results of the noise generated by the system burner-furnace. The comprehensive design solutions of reducing the noise intensity were also proposed. Besides, the paper presents the results of the acoustic emission of energy conversion processes from heating equipment. The solution to the problem of excessively high noise emissions from technological aggregate was proposed.
**Key words:** energy conversion, acoustic emission, heating equipment.

**Analiza buke tehnološkog agregata pokretanog tekućim gorivom.** U radu su prikazani rezultati ispitivanja emisije buke tehnološkog agregata - peć za spajanje čestica koja je pokretana na tekuće gorivo. Članak prikazuje rezultate istraživanja buke koju proizvodi sustav gorionika - peći. Predložena su također sveobuhvatna dizajnerska rješenja za smanjenje intenziteta buke. Osim toga, rad prikazuje rezultate zvučne emisije procesa pretvorbe energije opreme za zagrijavanje. Predloženo je rješenje problema previsokih emisija buke tehnološkog agregata.
**Ključne riječi:** pretvorba energije, zvučna emisija, oprema za zagrijavanje.

## INTRODUCTION

The noise is a subjective concept of adverse sounds of different frequencies impact on the human that cause especially fatigue and distraction. The noise emission is inseparably linked to the implementation of technological processes. The vibro-acoustic research of any object determines the mechanical causes and nature of the phenomenon. The mechanism of vibro-acoustic signals generation may be mechanical and gas-dynamic. It should be noted that the vibration and noise of machinery and equip-ment are closely related to their condition [1].

The gas-dynamic noise is associated with the movement of fluids, both compressible and incompressible. The noise accompanying the combustion process is characterized by the broadband nature with the dominant frequency subsidiary of the substrates speed flow [2-5]. The generated power of the noise depends on the combustion nature and during the stationary combustion it is proportional to the fourth power of the media outflow speed [6].

$$N_a \approx \frac{\rho \cdot w^4 \cdot l^2}{c} \qquad (1)$$

where: $N_a$ [W] – sound power,
$\rho$ [kg/m$^3$] – density of the fluid,
w [m/s] – fluid outflow speed,
c [m/s] – sound speed in the medium,
l [m] – characteristic dimension of the stream.

## RESEARCH OBJECT

The research was conducted at the industrial object (the furnace for joining the cutting elements). The furnace works intermittently and is powered by diesel fuel. The technological process occurs in conditions of the half-enclosed space. The opened charging door is located on the sidewall. That door is also used for the control. There is only the one burner (210 kW) installed in the furnace. The heat load volume of working chamber calculated from the formula

$$\dot{q}_V = \frac{\dot{m}_{ON} \cdot W_{dON}}{V_{kr}} \qquad (2)$$

where: $\dot{q}_V$ [kW/m$^3$] – heat load of chamber,
$\dot{m}_{ON}$ [kg/h] – fuel stream (diesel),
$W_{dON}$ [kJ/kg] – calorific value of fuel,
$V_{kr}$ [m$^3$] – volume of working chamber.

Is about 1400 kW/m$^3$. This value greatly exceeds the recommended typical values for heating furnaces, amounting to a maximum of 300 kW/m$^3$. This shows excessive intensification of technological process and it is the direct cause of the noise emission from the object [7, 8].

## THE TESTING OF NOISE EMISSION THE TECHNOLOGICAL PROCESS OF CUTTING ELEMENTS

The research was conducted in conditions of typical process efficiency (substrates pressure - 0.47 MPa, heat output - 200 kW). The scope of the research included: the measurements of noise levels with closed and open the door of the room in which the soldering furnace is, evaluation of the flame stability, specifying the length of the flame.

The noise measurement was conducted in 2 measuring points (0). An equivalent level of $L_A$ and $L_{LIN}$ and the noise frequency distribution in the octave-band was defined. The noise spectrum and the measurement results of the equivalent sound level are presented in 0. According to research, the limit value equivalent sound level in the workplace is much exceeded (approx. 30 dB (A)) [9]. The nature of the noise generated is broadband, and dominate the components values above 100 dB - occur in the range from 125 Hz to 4 kHz. While the maximum values of intensity (115 - 116 dB) has been noted in the octave-band of 500 Hz.

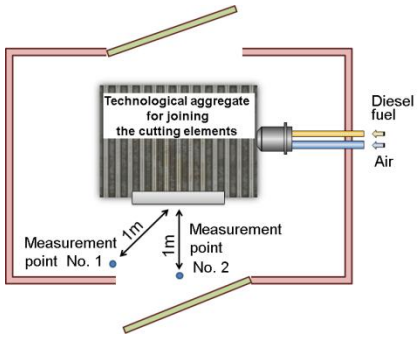


**Figure 1.** The points location of the sound-level measurement in the production room
**Slika 1.** Točke mjesta mjerenja zvučne razine u sobi za proizvodnju

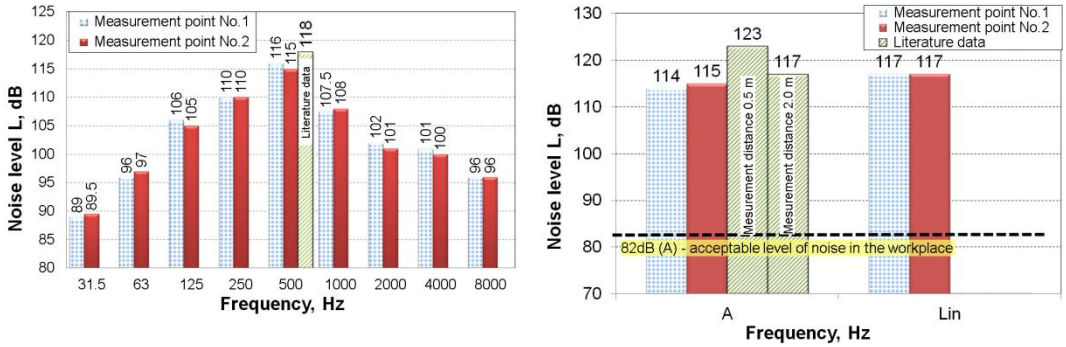


**Figure 2.** The results of the noise measurement during the process of joining the cutting elements (the noise spectrum and equivalent sound level)
**Slika 2.** Rezultati mjerenja buke tijekom procesa spajanja čestica (spektar buke i ekvivalentna razina zvuka)

## THE ANALYSES OF THE NOISE EMISSION GENERATED BY TECHNOLOGICAL PROCESS

The research results of noise emissions from soldering furnace have been compared to the literature data, i.e.:

- for the fast-flame natural gas burners, characterized by the high speed flow of about 200 m/s, with a heat power of 60 and 125 kW, the noise level is as follows:
  - at a distance of 0.5 m respectively 115 and 123 dB (A),
  - at a distance of 2.0 m respectively 105 and 117 dB (A) [10] – (0),

- for the combustion of natural gas and black oil the biggest noise level values was found in the octave-bands 31.5-1000 Hz with a maximum for 500 Hz [11].

At the time of research it was found that the production process is carried out by an unstable, detached the flame. This causes the combustion process is partially outside of the chamber. The flame detachment is due to the stream turbulence which appears already at the outlet of the burner nozzle. The condition for stable combustion is the equality maintenance between the speed of combustion and flow speed component.

Flame detachment is extremely disadvantageous, because it generates an increase in the level of sound intensity in the combustion process and it is dangerous for the operation of soldering furnace.

## THE METHODS TO REDUCE THE NOISE EMISSION OF THERMAL EQUIPMENT

The risk of excessive acoustic emission must be considered and solved in the system: source - the propagation of sound - human. The main cause of noise generated in the industrial objects is the acoustic emission from fans - which can be caused by aerodynamic or mechanical causes. The dominant role is played by the aerodynamic

noise [12-14]. One of the methods to reduce the fan noise emission is the change of the fan's point of work and it should be done due to the optimum of its acoustic characteristics. Account should be taken of the fact that this change can not affect the technological parameters of the industrial installations [15, 16].

The noise reduction, through structural changes or changes in the process, is not always possible to achieve. In such cases, the best solution is to use a sound absorbing housing. It represents a method of passive noise reduction. The multilateral screens are the effective means of direct noise reducing [6, 17]. The most commonly used in industrial environments are the walls made of the steel plate, filled inside by the damping mass or some sound-absorbing materials [18]. It should be noted that the screens are less effective for the low frequency.

The following solution (for noise reduction) has been proposed for the considered case:

- performance the perforated metal casings (from the sound source)
- use the layer filling of mineral wool
- fill with layers of mineral wool,
- performance the ribbed metal casings (from the outer side).

The proposed construction ensures self-supporting and large sound absorption coefficient $\alpha = 0.7\text{-}0.9$. Due to the deflection of the sound waves around the acoustic screen the greatest effectiveness will be demonstrated for frequencies higher than 50 Hz, for $\lambda < 0.6$ m.

## CONCLUSION

The research results of equivalent sound level $L_{Aeq}$= 114-116.5 dB in the workplace (near the furnace) indicate the excessively high noise emissions. The permissible acoustic noise levels in the European Union countries ($L_{Aeq}$= 82 dB) has been exceeded from 32 to 34.5 dB.

Based on studies, it was concluded that in order to optimize the combustion process should:

- use the active methods to reduce the gas-dynamic noise, mainly construction and parameters optimization of combustion system operation - estimated effect $\Delta L \approx 15$ dB (A),
- use the comprehensive passive methods i.e.: acoustic and sound-absorbing regimes - $\Delta L \approx 25$ dB (A).

Application of the proposed arrangements should reduce the noise emission to an acceptable level and additionally to reduce the harmful radiant heat of exhaust which is extracted from the chamber.

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