# EMPIRICAL STUDY ON NOISE EMISSION OF GAS TURBINES

FIRST INTERNATIONAL CONFERENCE on INDUSTRIAL GAS TURBINE TECHNOLOGIES
10 – 11th July 2003, Crowne Plaza Hotel, Brussels

# *Contents*

## *1. Introduction*

? In the study, **analysis of low frequency noise emissions of gas turbine** is presented.

? The **main goal** of the study was above all **to determine significant noise-sources on the observed object.**

? The **empirical basis** for **determination of causal-relationship** between **low frequency noise emission** and its possible **generators on the object** is presented.

## 2. Legislation

Slovenian legislation concerning noise emissions in the presented case restricts noise emission with values, pointed out in **Table 1**.

**Table 1**. Boundary values of noise level in living space.

| Respective region of living space | Boundary values dB(A) | |
|---|---|---|
| | Night-value Ln | Day-value Ld |
| National parks, vicinity of hospitals, health resorts | 40 | 50 |
| **Residence regions** | **45** | **55** |
| Mixed (residence - industrial) | 50 | 60 |
| Industrial areas | 70 | 70 |

- ? **Limitations in the frequency region** are **determined** with **differences between values of neighbouring-zones in logarithmic spectra**.
- ? **The boundary values were not exceeded**, however the residents living in the vicinity of power plant reported about sensing **low frequency noise**.

# *3. Identification of low frequency noise sources*

To identify further possible measures for low frequency noise reduction, **measurements of noise emissions were performed**;

It was stated that the **highest influence on the noise at nearest neighbours**, have the **stack outlet** and the **elbow at the entrance to the stack**.

**Noise spectrum at the stack outlet** has accented lowest frequencies from 10 to 25 Hz.

**Noise spectrum at measurement positions located at nearest neighbours** of power station is very similar to the noise spectrum of the stack outlet.

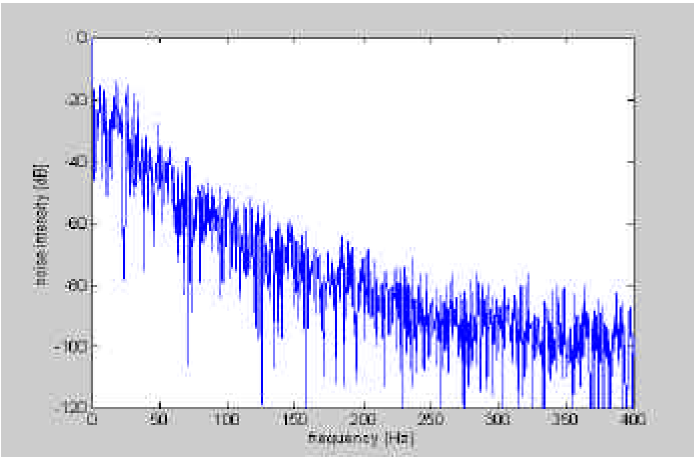


**Figure 1**. Noise power at **stack outlet**.

# 3. Identification of low frequency noise sources

? Noise spectrum of the **elbow at the entrance to the stack** has peaks at frequencies 22 to 33 Hz and 100 to 125 Hz.

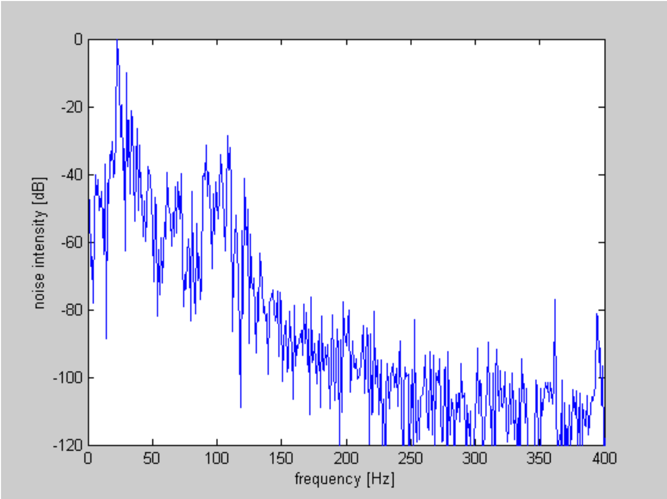


**Figure 2**. Noise power of the **elbow at the entrance to the stack**.

? Noise spectrum of the **inlet collectors** has besides peak at low frequencies also some narrow bands at higher frequencies, which are the most possible consequence of rotating sources.

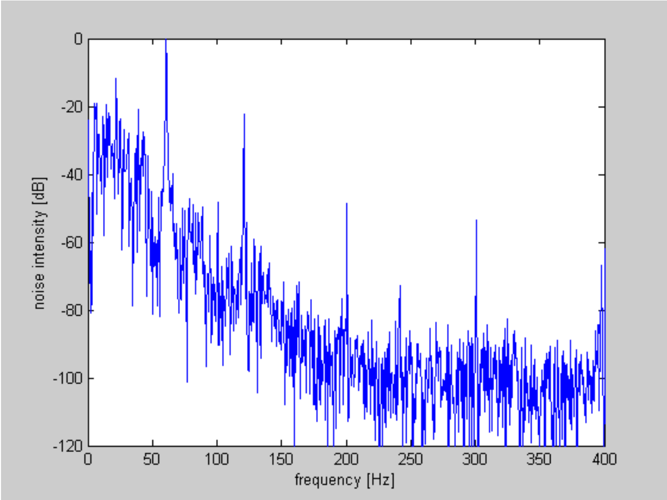


**Figure 3**. Noise power **upstream of inlet collector** – air filter.

# 3. Identification of low frequency noise sources

For the estimation of the influences of low-frequency noise on the surroundings, within the frame of the presented study, the measurements of noise power on respective selected locations in the vicinity of power station were performed.

Besides the level of sound power, also the structures of frequency spectra were analysed. In **Figure 4**, typical power spectrum at the boundaries of power station is presented.

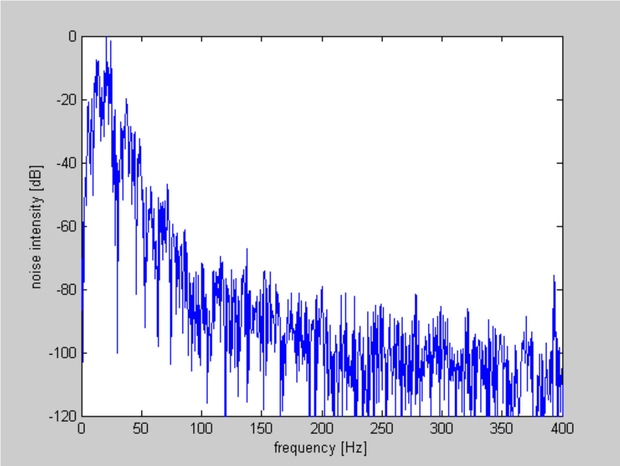


**Figure 4**. Typical structure of spectral noise power at the boundaries of power station.

From the presented results it is obvious that the low-frequency part of the sound-power at the boundaries of power station is preserved.

# *4. Relationship low-frequency noise - noise sources*

Possible **causal relationship between observed low-frequency noise** and **fluctuations of** other **mechanic and thermodynamic parameters** which accompany the observed process were investigated.

The **research** was **directed to identification of mutual relationship of acoustic emission at the elbow** upstream of the stack inlet and **selected parameters which were observed on the segment of the gas turbine flow tract**.

**As mechanic – dynamic quantity**, vibrations on the surface of the elbow front plate upstream of the stack inlet were measured.

**As an indirect thermodynamic quantity**, the pulsing of light intensity in the combustion chamber of gas turbine was measured.

# 4. Relationship low-frequency noise - noise sources

**Figure 5**. Installation of optical sensor.

**Figure 6**. The view of the gas turbine combustion chamber.

# 4. Relationship low-frequency noise - noise sources

The following variables were simultaneously measured:

? LIGHT INTENSITY IN THE COMBUSTION CHAMBER
(photocell was installed at the top of the combustion chamber)

? NOISE IN THE NEAR FIELD OF THE ELBOW
(instrument Bruel & Kjaer 2237)

? VIBRATIONS OF THE STACK ELBOW
(accelerometer Bruel & Kjaer 4332, amplifier Bruel & Kjaer 2635)

## Results

Frequency spectrum of the light intensity in the combustion chamber (**Figure 7**) shows increased fluctuations at frequencies below 50 Hz.

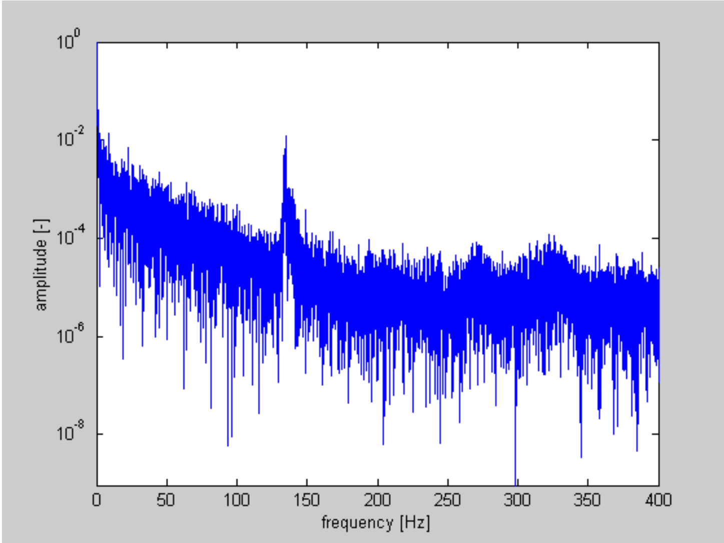


**Figure 7**. Linear narrowband spectrum of light intensity in the combustion chamber.

Cross correlation and transfer function between light intensity in the combustion chamber
and noise in the near field of the stack elbow show their interdependence.

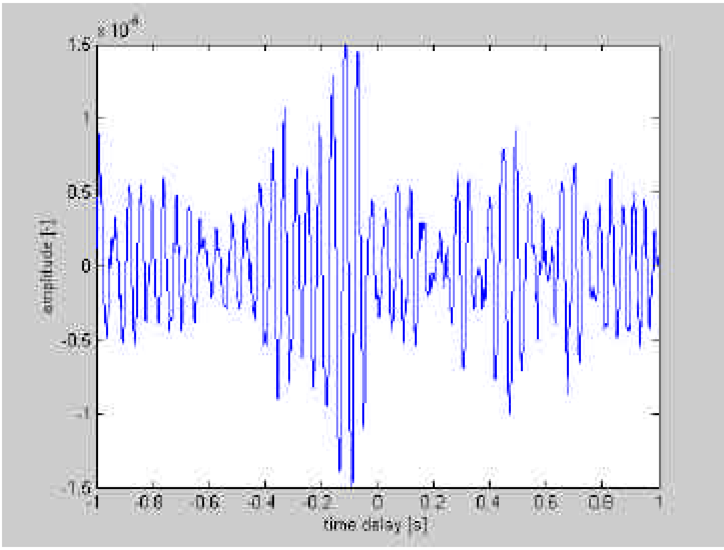


**Figure 8**. Cross correlation; light intensity-noise.

# 4. Relationship low-frequency noise - noise sources

Similar interdependence was found between stack elbow vibrations and the noise in the near field of the stack elbow.

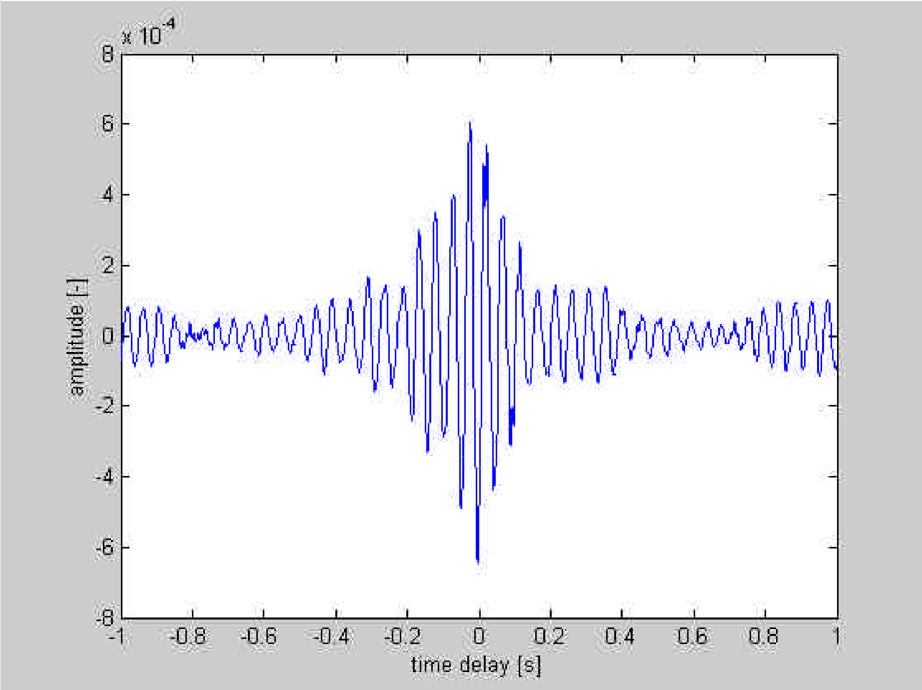


**Figure 9**. Cross correlation; stack elbow vibrations-noise.

From these figures follows that fluctuations of very low frequency below 50 Hz are produced in the combustion chamber. These are then transferred through the stack elbow structure vibrations to the outside as low frequency noise.

# 5. Conclusions

From cross-correlation function a quasi-periodic, non-linear nature of the relationship between optical pulsations in the combustion chamber of the turbine and signal of acoustic emission outside the flow tract is evident, where the “driving” signal is optical pulsation which is, with a phase shift, followed by acoustic response.

Optical signal as indicator of non-stationary thermodynamic disturbance, which in the form of small pressure disturbance emanates through the turbine flow tract, connects it with a signal of acoustic emission which in the observed case is a consequence of the pressure disturbance.

Further work: measurements of optical intensity should be performed with aid of a high-speed camera from more optimal observation point, using suitable optics and pressure transmitters in the combustion chamber and in the elbow. The method would enable identification of local phenomena in the combustion chamber and their direct connection with acoustic effects from the outside.