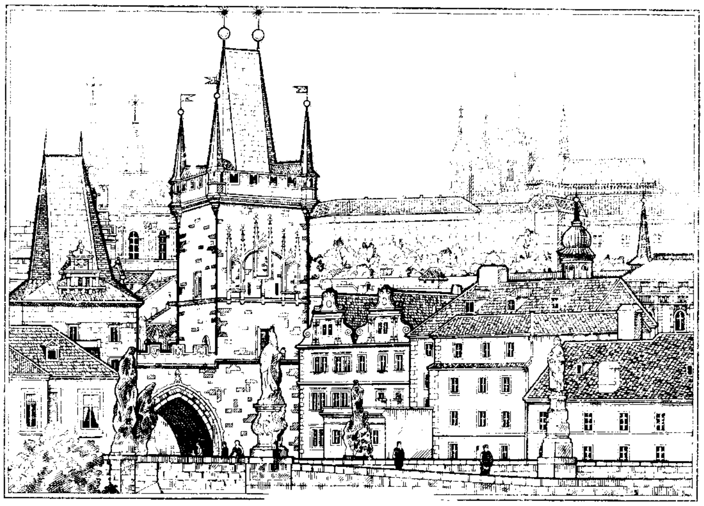
International Association against Noise
Internationale Vereinigung gegen den Lärm
Association Internationale contre le Bruit

A I C B

17th AICB Congress

30th Conference of Acoustic - ČSAS

THE AIMS FOR NOISE CONTROL IN EUROPE OF THE FUTURE



23 - 25 June 1992
Prague - Czechoslovakia

COMBUSTION ENGINE NOISE SOURCES IDENTIFICATION

❒ B-2-09
K. VOKURKA
Jablonec n.N., ČSFR

Summary
Identification of noise sources usually represents the first task in any noise reduction programme. A number of methods, such as lead uncovering technique, surface sweeping with a sound intensity probe etc. are currently used in connection with combustion engines. This paper describes the experience gained in LIAZ Co. with a method based on measuring engine noise level variations concurrently with engine speed and sound intensity maps on a test grid enclosing the engine surface closely. These noise characteristics are determined both for total noise levels and for selected third-octave bands. The method is illustrated by the measured data.

1. Introduction

Noise reduction of combustion engines represents a demanding task. To solve it successfully, one needs to know both the noise generating mechanisms in the engine and the relative importance of different noise radiating surface areas well. With respect to the generating mechanism, the total noise can be separated into combustion and mechanical parts. In the case of turbocharged engines, combustion noise usually plays only a minor role and it is mechanical noise which dominates the overall noise.

In the engine, noise propagates from the sources through the structure to the surface, where it is radiated into a surrounding space. As the surface areas radiate noise with different intensities, then at the beginning of any noise reduction program it is necessary to rank the areas according to radiated noise. It is also very important to identify those parts which resonate at certain engine speeds.

To rank the radiating areas according to the emitted noise levels, several methods can be used, for example, a near field sound pressure measurement, sound intensity measurement, and lead uncovering technique. The author's experience with the latter technique is described in Ref. [1]. In this paper a simple method used in LIAZ Co. for fast location of resonant parts will be dealt with.

2. Method

The method for fast identification of resonant parts consists of the following steps:

a) Measurement of the total acoustic pressure level variations with increasing engine speed (during this test the engine is at the full load and the speed is being slowly increased within the working range).

b) At the engine speeds, $n_{tot\ max}$, corresponding to the local maxima ofthe variations determined in a), the third-octave spectra are measured. At these spectra, bands corresponding to spectral peaks, $f_{1/3\ peak}$, are determined.

c) Measurement of the acoustic pressure variations with increasing engine sped in the third-octave bands, $f_{1/3\ peak}$, as selected in b). The engine speeds, $n_{1/3\ max}$, corresponding to the maxima at these variations are determined.

d) Sound intensity maps, on a surface close to the engine, are measured. The engine speed is set $n_{1/3\ max}$ and the sound intensity maps are calculated for frequencies $f_{1/3\ peak}$.

During the tests according to a) through c) microphones are positioned in measurement points shown in Fig. 1. The microphone outputs are fed into a measuring amplifier (B&K 2607). The sound intensity maps are measured on a square grid of points 0.2 m apart as shown in Fig. 2.

The measurements of the acoustic pressure level variations with the engine speed (points a) and c)) are accomplished using an XY recorder. A signal proportional to the engine speed (supplied by a dynamometer) is fed to a X input of the recorder. An output signal from the measuring amplifier, which is proportional to the sound pressure level, is fed to a Y input of the recorder. The engine speed is varied slowly, the time needed to get from the lowest to the highest speed being approximately 120 s.

The spectra under point b) are measured by a third-octave analyser (B&K 1617 and B&K 2307). The sound intensity maps (point d)) are measured by a sound intensity probe (B&K 3519) connected to a dual channel signal analyser (B&K 2034). The data are processed by a personal computer.

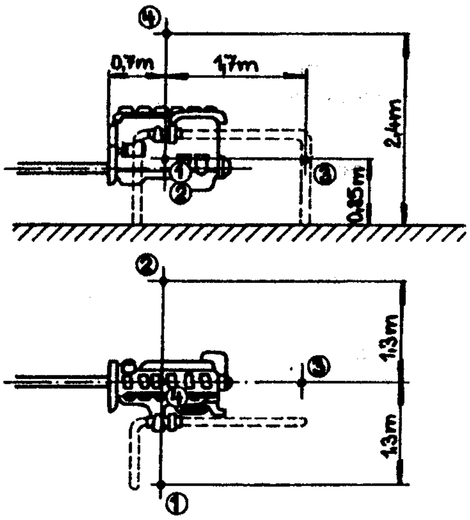


Fig. 1
Basic microphone positions

3. Results

As an example of the method, results obtained during noise reduction work on LIAZ M2-650 engine [2] will be given.

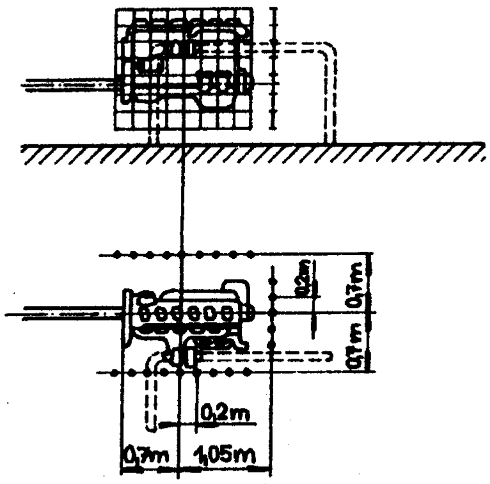


Fig. 2
Grid of the measuring points for determination of the sound intensity maps

The measured variation of the acoustic pressure level with engine speed is shown in Fig. 3 by a full line. On this graph, a noise maximum at an speed $n_{tot\ max}$ 1950 min^{-1} can be clearly seen. Such a maximum can be due to a resonance of some part.

A third-octave spectrum was measured at the speed $n_{tot\ max}$. This spectrum is shown in Fig. 4. In Fig. 4, the spectral peak can be seen in the band $f_{1/3\ max}$ = 400 Hz. To verify that this resonance is responsible for the

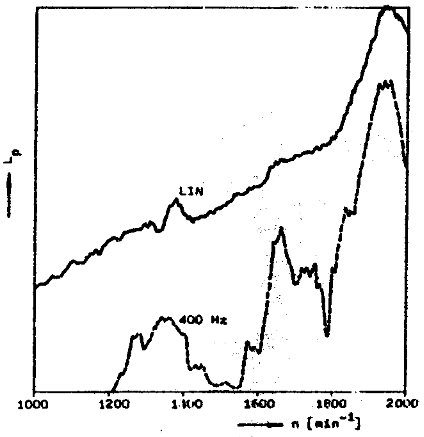


Fig. 3
Variation of the sound pressure levels at the microphone position 3 with the engine speed

maximum found at the speed $n_{tot\ max}$, the measurement of the pressure level variation with the engine speed was repeated. However, now the output signal from the third-octave band $f_{1/3\ max} = 400$ Hz was recorded (Fig. 3, a broken line). As can be seen, the assumption that the maximum at $n_{tot\ max}$ is due to this resonance was verified.

In the next step the resonant part was located. For this purpose, a sound intensity map was measured at a frequency 392 Hz (this frequency corresponds exactly to the peak in the spectrum). The sound intensity map obtained is shown in Fig. 5. As can be seen in this figure, the sought part is an engine front cover, where, at speed $n_{tot\ max}$ 1950 min^{-1} a basic panel resonance is excited.

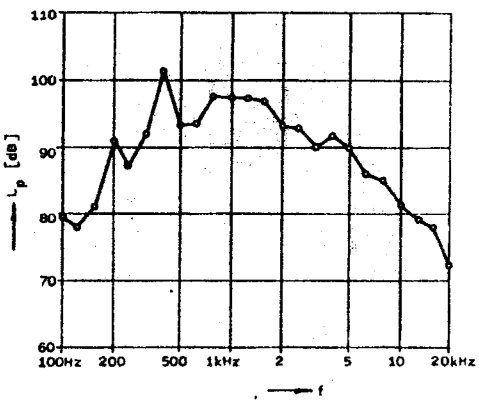


Fig. 4
Third-octave spectrum of noise at microphone position 3. The engine speed n=1950 min^{-1}, full load.

4. Conclusion

Using the method described above it was possible to identify 4 significant resonances of the LIAZ M2-650 engine's parts. The advantage of the method is its speed - the measurement and processing of all the data could be done in two days. Thus the method can be used for fast introductory surveys carried out prior to more sophisticated techniques, such as a modal analysis.

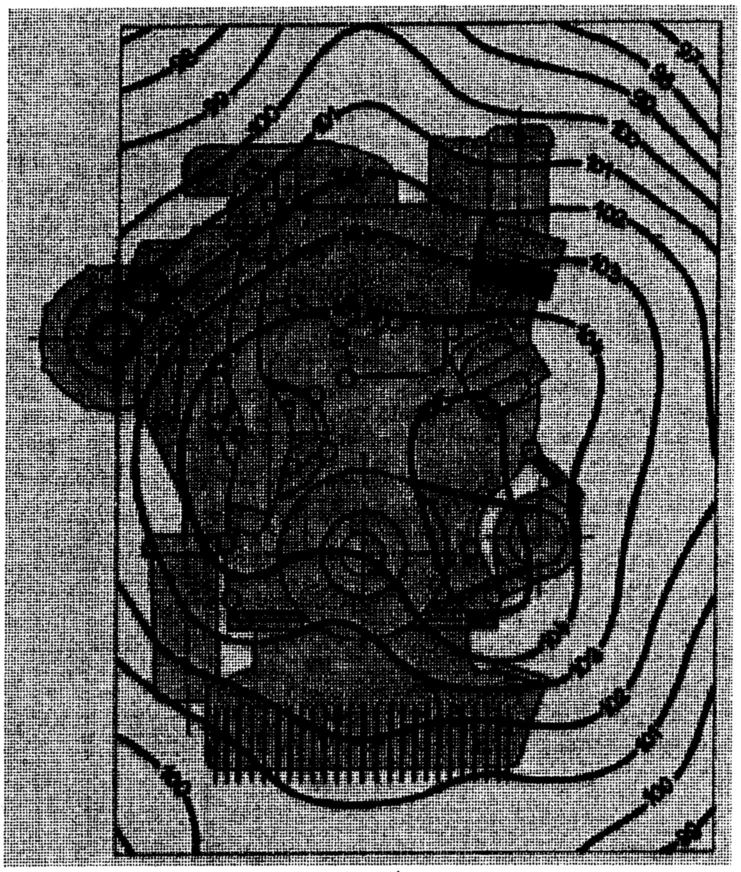


Fig. 5
Sound intensity map for f=392 Hz measured in front of the engine at speed n=1950 min^{-1} and 50% load

References

[1] Vokurka K.: Identifikace zdrojů hluku motoru. 15. konference kateder a pracovišť spalovacích motorů čs. vysokých škol, Liberec 5.-6.6.1984 (Dům techniky ČSVTS Ústí n.L., pracoviště Liberec, 1984) str. 73-77.

[2] Vokurka K.: Vliv použití pístů ALCAN na hluk motoru M2. Zpráva č. 12/89, s.p. LIAZ Jablonec n.N., stř. 10-292, březen 1989.