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[N670] Noise Impact of Absorption Machines for Civil Applications

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ABSTRACT

Absorption Machines (AM) are known as low noise devices; thus, they are employed when silence requirements are very severe as like hotel rooms, hospital rooms, etc. Big size AM noise emissions may be anyway remarkable. This work deals with an experimental investigation aimed to determine the characteristics of AM noise emissions on nominal working conditions. Measurements have shown that AM power spectrum is mainly characterized by frequency components equal and higher than 400 Hz. Noise abatement solutions have been proposed and discussed.

KEYWORDS: Absorption machine, Noise emissions, Refrigeration

INTRODUCTION

Heat and electricity generation for civil applications is today obtained by single low power wall-boilers and solar panels. Fuel cells will be employed in the next future jointly with refrigeration machines. Thus, wide interest is given to Absorption Machines (AM) for cooling and heating civil applications. In fact, AM are characterized by low noise emissions with respect to the Compression Machines (CM) ones; electrical and mechanical devices such as electrical engines, compressors and pumps are not used to get an absorption refrigeration cycle [1]. However, noise levels caused by a high power AM may be particularly annoying. A measurement campaign has been carried out to individuate noise emissions characteristics of a commercial AM; the refrigerant-absorbent mixture is H_2O-LiBr, which is the most common mixture for building refrigeration applications [2]. Measurement results have shown very low noise power levels with respect to a same power CM. Noise abatement solutions have been proposed in compliance to machine geometrical configuration and noise power spectrum distribution.

ABSORPTION MACHINE CHARACTERISTICS

Measurements have been carried out on a single stage no-sheltered AM (Yazaki, model WFC 5) connected to a custom refrigerating plant which has been realized at the Perugia University Thermophysics Laboratory [3]. The system scheme is shown in Fig. 1.

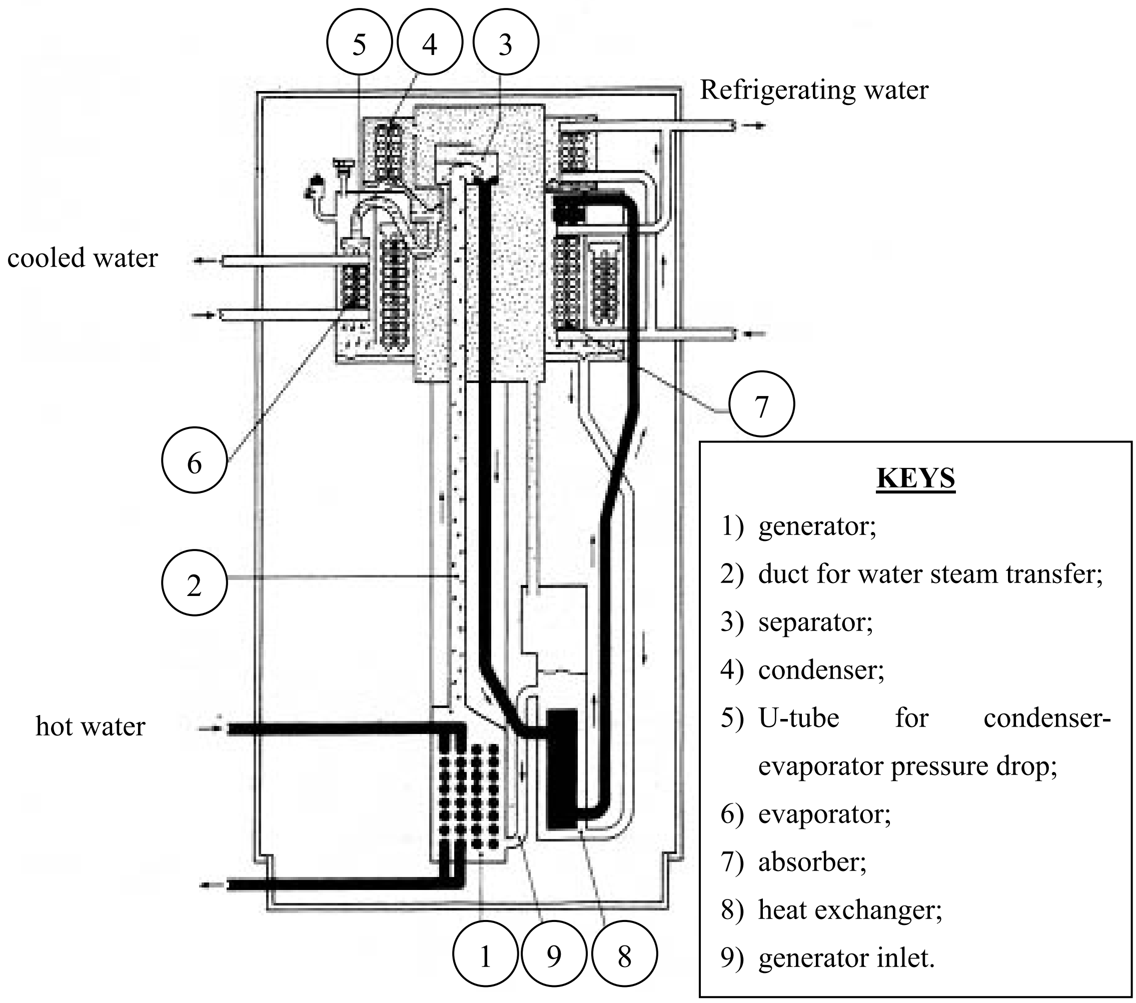

Figure 1: AM scheme

Refrigerating plant and machine characteristics are the followings:
- refrigerant is water;
- absorbent is Lithium Bromide (LiBr);
- 17kW refrigerating power;
- hot water flow rate equal to $1.157 x 10^{-3}$ m^3/s (88°C water temperature);
- generator maximum working pressure equal to 98kPa;
- evaporator maximum working pressure equal to 295Pa;
- cooled water temperature is 9°C (flow rate $0.83 x 10^{-3}$ m^3/s);
- C.O.P. is 0.3 for 76.9°C hot source temperature (nominal working conditions).

Absorber and condenser refrigerating circuit is characterized by a $2.22 x 10^{-3}$ m^3/s water flow rate and a 295kPa maximum pressure; inlet and outlet refrigerating water temperatures are respectively 29.5°C and 34.5°C. Nominal working conditions are obtained after three hours from the machine switch on. Mixture moving is obtained by pumping devices in traditional AM. The investigated AM is instead characterized by a natural mixture moving by bubbling and pressure drop phenomena.

MEASUREMENT METHOD

AM noise emissions on nominal working conditions have been studied. Acoustic pressure and intensity levels have been measured by means of Symphonie data acquisition system. Measurements have been led in 112 points placed on a fictitious 22.68 m^2 parallelepiped surface which surrounds the noise source (see Fig. 2) [4].

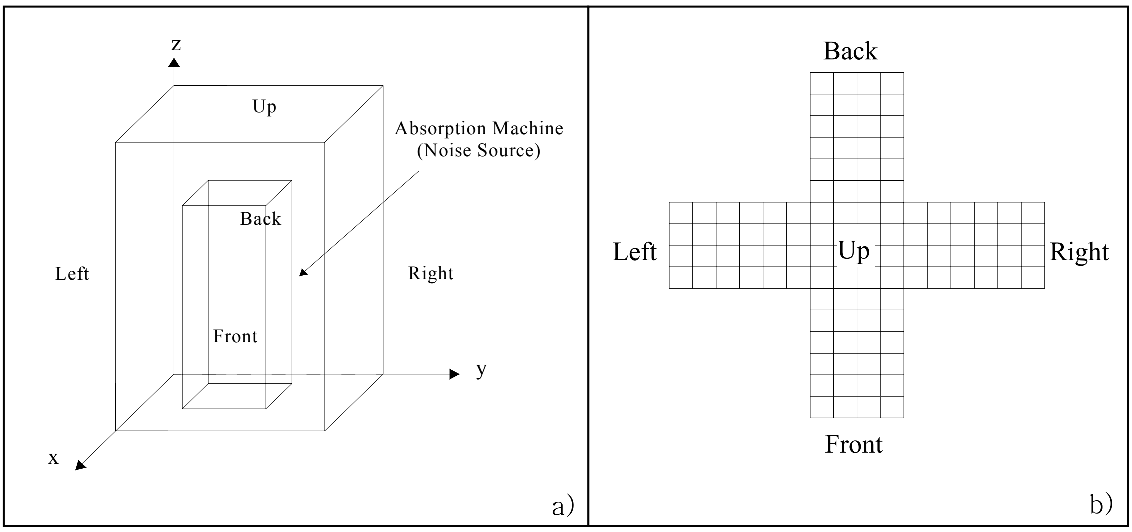

Figure 2: a) measurement surface; b) measurement points grid

Measurements points have been individuated in according to ISO 9614-1/93 [4].Noise source dimensions are x=0.72m, y=0.74m, z=1.9m (x–y plane is the wall the absorption machine is installed on).
Measurement surface dimensions are x=1.80m, y=1.80m, z=2.70m.
Measured intensity levels have been processed by the data acquisition system in order to calculate absorption machine noise power level. The intensimetric measurement campaign have allowed to not take into account noise emissions due to energy vectoring plant, hot source generation device and user.

MEASUREMENTS RESULTS AND DISCUSSION

AM A-weighted intensity level map and 1/3 octave-band power spectrum are shown respectively in Figs 3 and 4. The highest intensity levels (over 56dBA) occur in a) and b) measurement zones (see Fig.3):

a) high intensity levels are due to LiBr spots which strike generator and transfer duct walls (1 and 2 keys in Fig.1) during bubble upwarding;
b) high intensity levels in the up side measurement points are due to the vibration of the condenser caused by shocks during bubble upwarding.

High intensity levels (over 53dBA) occur also in c_1) and c_2) zones (see Fig.3); these are due to the vibration of evaporator during bubble upwarding.
A support panel covers the machine right side; thus, the lowest intensity levels occur for right side measurement points.
Results show that:

- main noise component frequency is 400 Hz;
- A-weighted sound power level is 65.9 dBA;
- linear sound power level is 66.8 dB.

Fig. 4 shows the comparison between sound power spectra due to the investigated AM and a CM characterized by the same refrigerating power (17kW) [5]. Noise generated by CM is characterized by:

- A-weighted and linear power levels higher than AM ones;
- low frequencies components caused by electrical engine/compressor system;
- periodicity due to 50Hz supply electrical power.

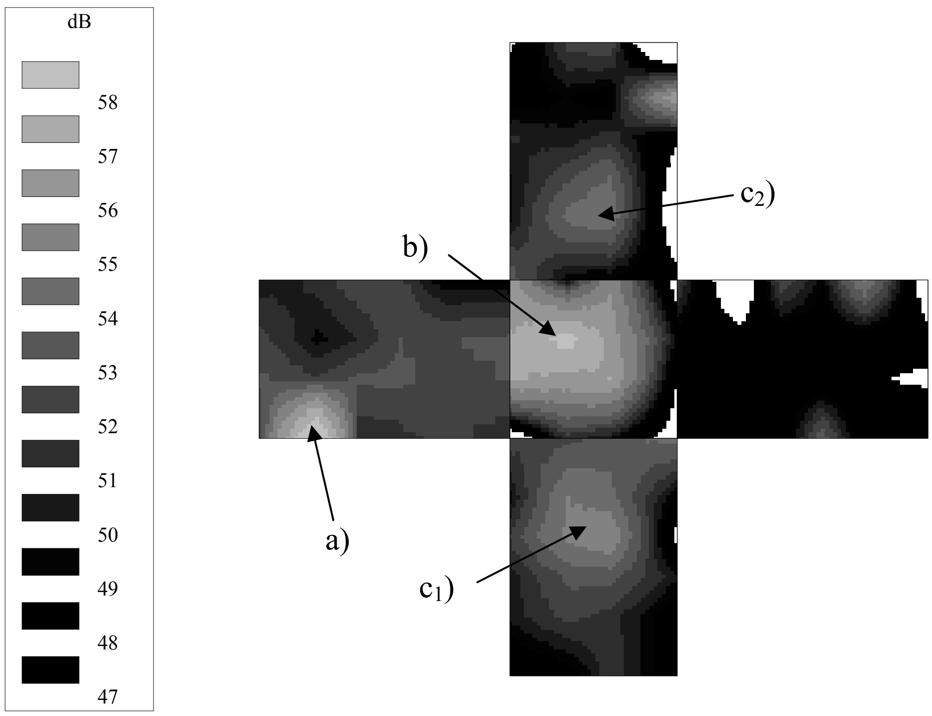

Figure 3: intensity levels map

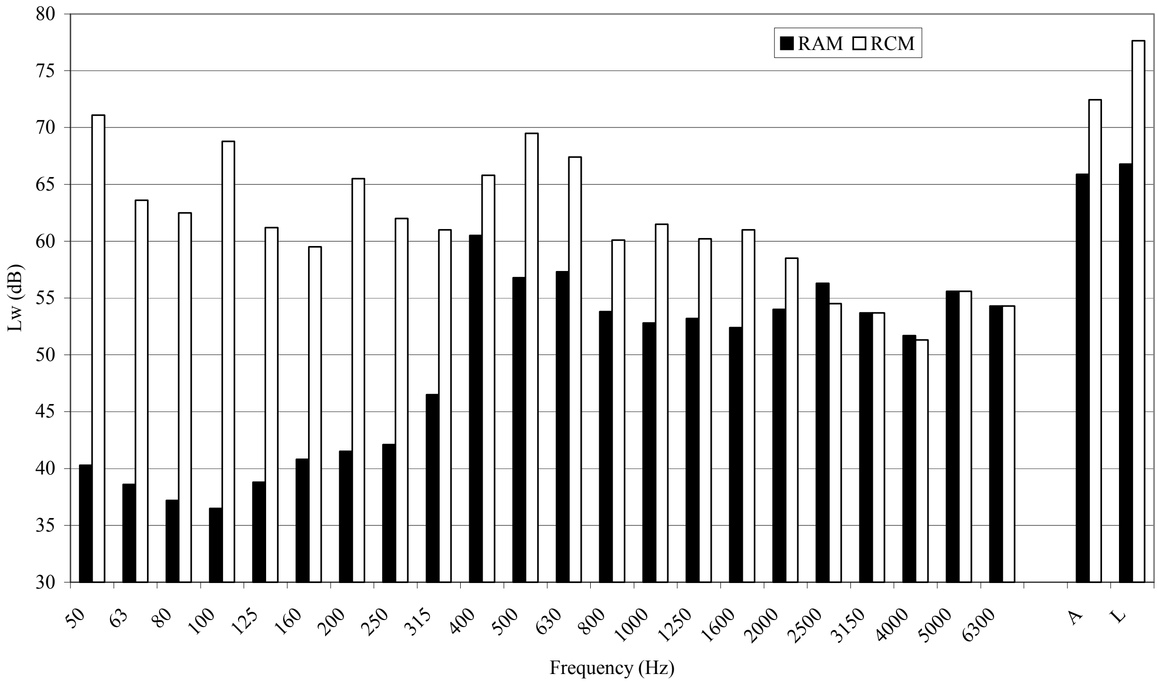

Figure 4: Noise level comparison between AM (black) and CM (white) of same refrigerating power (17kW)

NOISE REDUCTION METHODS

Porous sound absorbing materials allow to reduce noise emissions characterized by frequency components equal and higher than 400 Hz. Thus, the investigated machine has been insulated by means of 6 cm thick glass wool panels [6].

An intensimetric measurement campaign has been carried out to evaluate the proposed noise reduction method efficacy. Fig. 5 shows the comparison between noise power levels relative to the following conditions:

- before the realization of the proposed noise reduction solutions (BEFORE);
- after the realization of the proposed noise reduction solutions (AFTER).

The following noise level reductions have been obtained by means of the glass wool panels:

- 6.6 dBA (A-weighted noise power level);
- 6.3 dB (A-weighted noise power level).

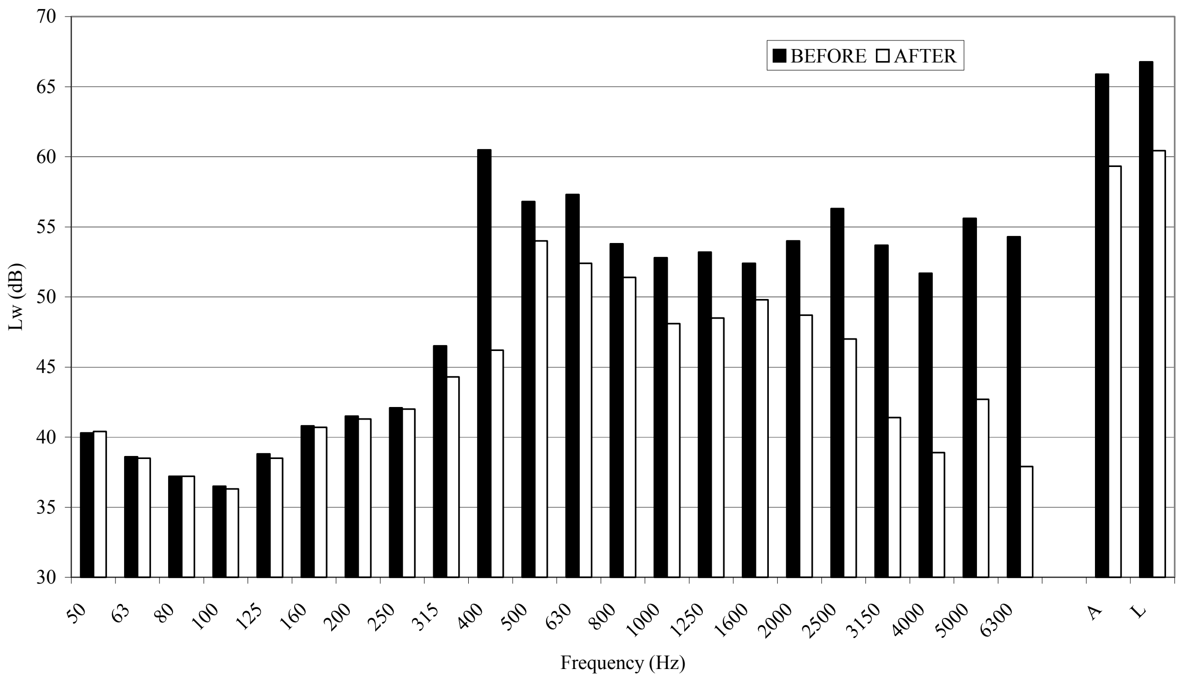

Figure 5: comparison between AM power levels in BEFORE (black) and AFTER (white) noise abatement

Higher noise reductions may be obtained by focusing acoustic insulation solutions in a) and b) zones (see Fig. 3), which are characterized by the highest noise emission levels.

CONCLUSIONS

A measurement campaign has been led to individuate noise emissions characteristics due to a H_2O-LiBr AM. Measurement results have shown that noise 1/3 octave-band spectrum levels are over 50dB only for frequency components equal and higher than 400Hz. AM A-weighted power level is 65.9 dBA. Noise emissions are mainly due to LiBr spots which strike generator and transfer duct walls during bubble upwarding and induce vibrations on condenser and evaporator. Noise reduction solutions have been proposed: the investigated absorption machine has been insulated by means of glass wool panels. A measurement campaign has been led to evaluate noise abatement. The obtained A-weighted noise power reduction is 6.6dBA. The comparison between noise emissions due to a AM and a same refrigerating power CM has shown that:

- single frequency components occur only for CM;
- AM noise spectrum is characterized only by high frequencies which may be easily reduced by means of porous sound absorbing materials;
- AM noise power levels are much lower than CM ones.

Thus, AM may be considered suitable for civil applications such as residential electrical-thermal supply by means of fuel cells. Fuel cell may be used to generate AM hot source. AM works as heat pump for winter season, as refrigerating machine for summer season.

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