INFLUENCE OF THE NUMBER OF EMITTER-RECEIVER COUPLES ON MEASUREMENT ACCURACY IN ACOUSTIC PYROMETRY

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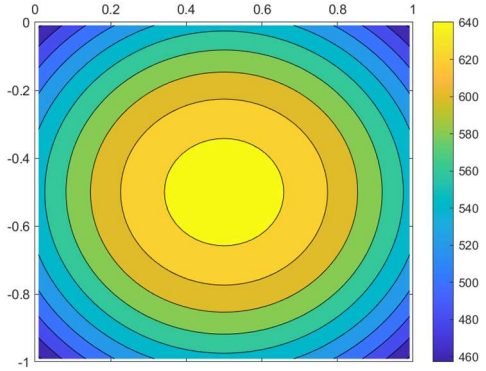
EXTENDED ABSTRACT

Acoustic pyrometry is an interesting technique that may find several useful applications in turbomachinery. This measurement technique is based on the estimation of the temperature by considering the time of flight of an acoustic wave. If only an acoustic emitter-receiver couple is used, only the average temperature along the acoustic path can be determined. If multiple emitter-receiver couples laying on the same plane are used, a reconstruction of the temperature map in the section is possible. The estimation is performed by considering that multiple acoustic paths travel across the same sub-portions of the section and, therefore, the temperature of each sub-portion affects the time of flight along several sound paths. As the temperature of the fluid increases, the time of flight of an acoustic wave decreases and, for a fixed distance between the emitter and the receiver, the estimation of the time of flight becomes more and more critical (smaller time difference). Therefore this technique is particularly suitable for measuring the temperature distribution on large diameter ducts when the temperatures are medium-low, as in chimneys or boilers. In the turbomachinery field, potential applications might be related to the measurement of the temperature distribution in the exhaust duct of a gas turbine or in the heat recovery steam generator. The temperature in these sections is generally performed by using spot temperature measurement. A temperature distributions, instead of spot values, may lead to great benefits in terms of experimental characterization of the machines and detection of potential failures. In addition, the measurement would be performed by using externally mounted emitters and receivers with a reduced cost.

Beside these considerations, the accuracy of the measurement relies on several parameters, some of which are related to the hardware used and some to the procedure adopted for the reconstruction of the temperature map. In this study, the authors focused their interest to analyze the impact of some set-up parameters on the accuracy of the measurement. In particular, the impact of the number of sound emitter-receiver couples and the number of investigation sub-portions in which the section is divided have been investigated. A reference temperature map has been considered as a benchmark. This study, which is a preliminary investigation on this technique, was useful to assess the capability of this technique to correctly describe a temperature distribution in an ideal condition. Therefore, it represents a first step in the set-up of a measurement with an acoustic pyrometer.



Firgure.1 Temperature reference map.

Speed of sound in a section sub-portion:

$$a_i = \sqrt{kRT_i}$$

Time of flight along a sound ray:

$$\tau = \sum \frac{l_i}{a_i}$$

where l_i is the sound ray length in the section sub-portion

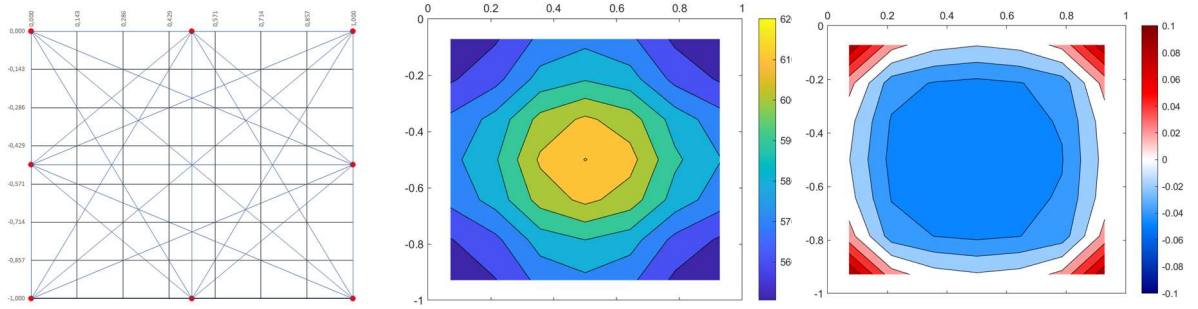


Figure 2. Sound rays, reconstructed temperature map and % error with 3 emitter-receivers per side

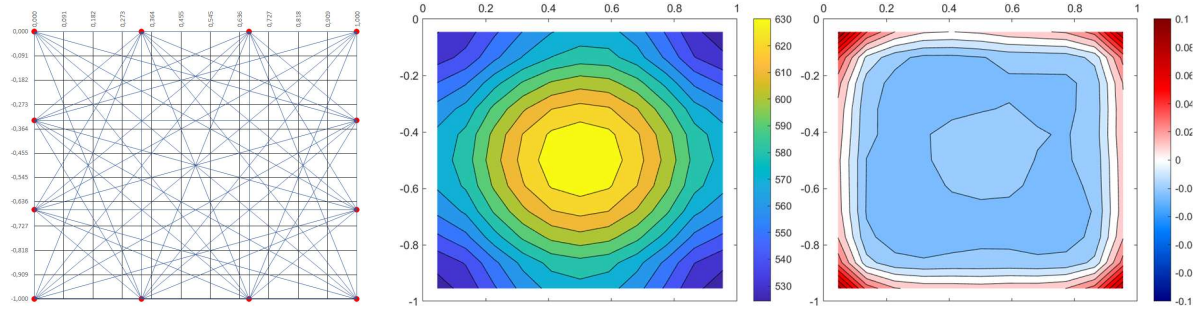


Figure 3. Sound rays, reconstructed temperature map and % error with 4 emitter-receivers per side

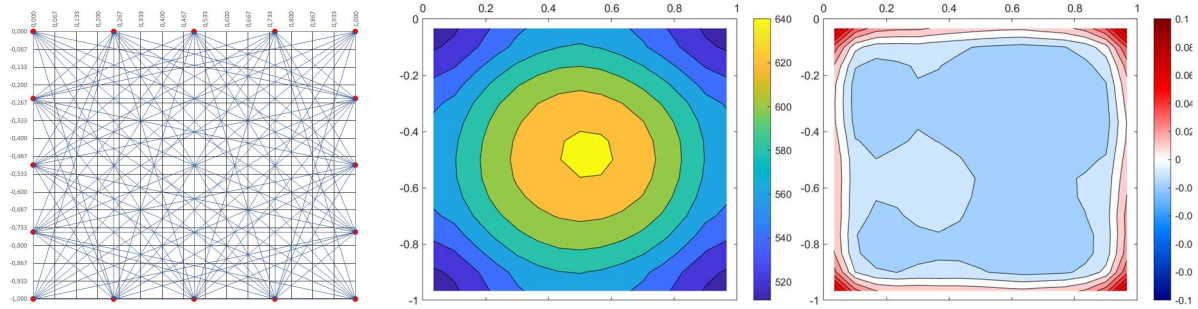


Figure 4. Sound rays, reconstructed temperature map and % error with 5 emitter-receivers per side

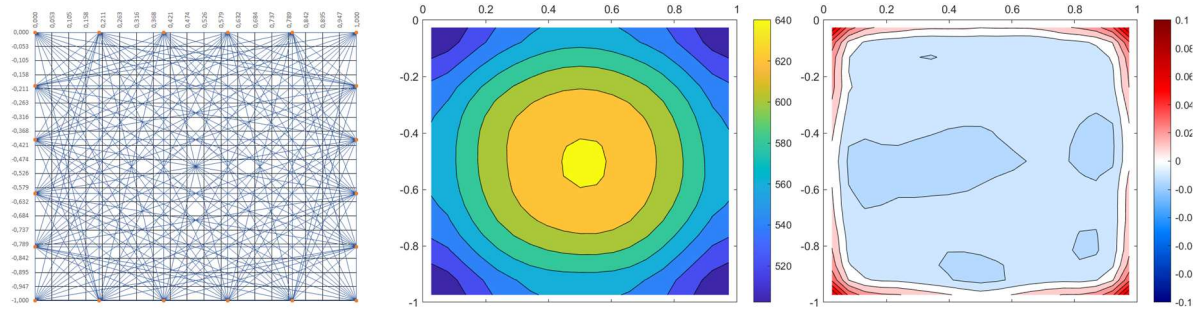


Figure 5. Sound rays, reconstructed temperature map and % error with 6 emitter-receivers per side

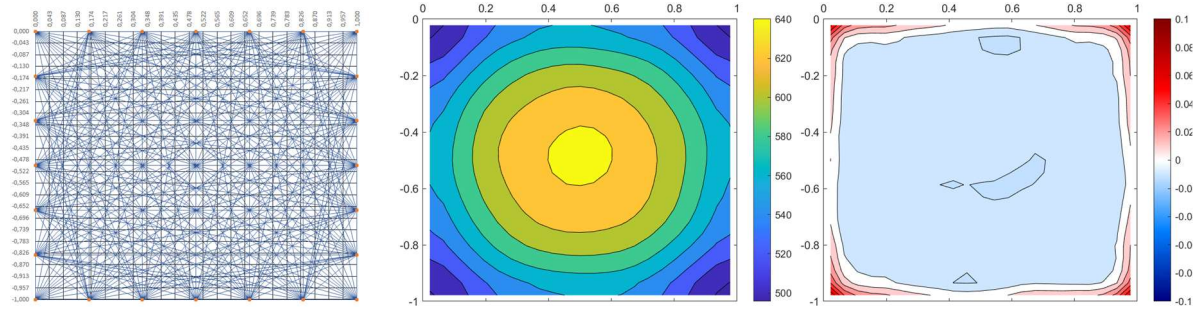


Figure 6. Sound rays, reconstructed temperature map and % error with 7 emitter-receivers per side