STATISTICAL ANALYSIS OF DIFFERENT ABSORBER TARGETS FOR ULTRASONIC RADIATION FORCE MEASUREMENT

Rodrigo P.B. Costa-Félix[1,2], *André V. Alvarenga*[1]

[1] Laboratory of Ultrasound – Diavi/Dimci/Inmetro, Duque de Caxias, RJ, Brasil, labus@inmetro.gov.br
[2] rpfelix@inmetro.gov.br

Abstract: Ultrasonic power measurement in the megahertz frequency range is undertaken accordingly to the physical principle of radiation force. In this case, a device named "radiation force balance" is habitually used for output powers lower than about 20 W. The construction of a radiation force balance presupposes the use of either a reflecting or an absorbing target. In this paper, it is detailed a statistical analysis of 4 different absorbers targets used in an implementation of a radiation force balance measurement device.

Key words: ultrasound, power measurement, statistical analysis, absorber target, metrology.

1. INTRODUCTION

Ultrasonic power is one of the most important parameter to qualify an ultrasonic device, particularly those equipments used in biological tissues (medical devices). The application of many technical standards demands the knowledge of the total output power in order to state the conformity accordingly to safety and essential performance [1][2]. In general, output ultrasonic power is measured using a radiation force balance as described in [3]. That standard suggests the use of a reflector or an absorber target. In the case of an absorber target, there is a rationale prescribing some ultrasonic characteristics: reflection factor <3.5% and absorption > 99%. Even so, the whole system should be considered validated if all assembling parts are working properly as a whole set unit. The aim of the present work is to present a statistical analysis of power measurement of an ultrasonic source using 5 different absorbers targets used in a radiation force balance.

2. MATERIAL AND METHODS

The main measured parameter was ultrasonic power as described in [3].

2.1. Equipment and instrumentation

The ultrasonic source was a continuous wave check source (Precision Acoustics, UK) with nominal working frequency of 3.5 MHz and 25.4 mm of nominal diameter submersible ultrasonic transducer (Olympus NDT – Panametrics, USA). The measuring device was a microbalance model CP224S (Sartorius, Germany) and some homemade specially designed assembly parts. Figure 1 shows a picture of the measuring system.

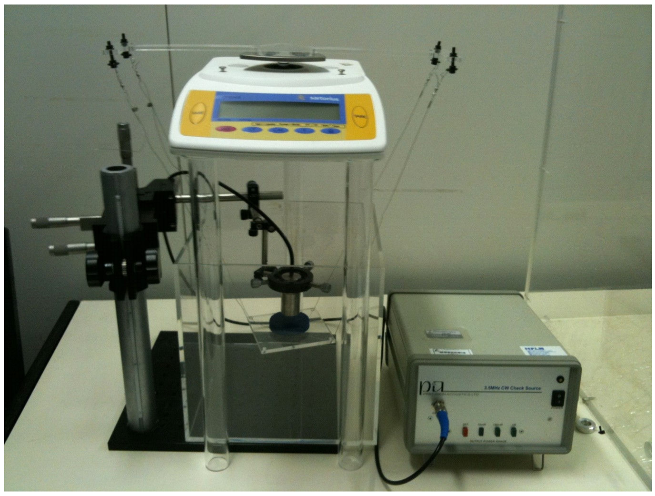

Fig. 1. Ultrasonic power measurement device: continuous wave check source, 3.5 MHz transducer, microbalance and assembly parts (no target is present).

2.2. Experimental procedure

Power measurements were done accordingly to prescriptions in [3]. In total, 4 measurements in repeatability conditions were performed for each target and at 3 different output nominal powers: 10 mW, 100 mW and 1 W.

2.3. Statistical analysis

For each output power, the setup with each target was considered as a weakly correlated measurement instrument. So, the standard error E_N was used as comparison parameter:

$$E_N = \frac{\overline{P} - P_i}{\sqrt{U_{\overline{P}} - U_i}}, \qquad (1)$$

where $\overline{P}$ is the average power for the 5 different targets, P_i is the power assessed using each one of the 5 targets, $U_{\overline{P}}$ is the combine expanded uncertainty and U_i is the expanded uncertainty for obtained with each target.

4. RESULTS, DISCUSSION AND CONCLUSION

In all cases, the standard error is less than 1. In a simple and straightforward analysis, the use of any of the absorber targets would lead to equal results, having the uncertainty as a comparison basis. Further than the simple evaluation of the ultrasonic absorption and insertion loss, the analysis of a set of power measurements are more likely to confirm the metrological equality of different assemblies of a given device or measurement system.

As a final conclusion, all targets evaluated in the present study could be considered statistically equal, so the use of either of them would not jeopardize the metrological reliability of the results.

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