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TEST RIG FOR CIRCULATOR NOISE MEASUREMENT

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INTRODUCTION

Previous studies [1], [2] have shown that hydraulic noise measurement seems to be the best way of characterising the acoustic behaviour of circulating pumps (compared to air-borne or structure-borne noise measurement). Moreover, the measurement of the pressure fluctuations in the liquid is the best adapted measure in characterising the acoustic energy emitted by the circulator acting essentially as a source of excitation through the pipes (either by the liquid or by the structure).

However, the hydraulic noise levels measured in the pipes depend on :

- the acoustic impedance of the circuit on which the circulator is connected
- the stationnary waves into the pipe, which totally modify the repartition of the acoustic field ; for any given frequency, the amplitude of the pressure fluctuations depends much on the transducers position into the pipe. These phenomena have to be taken into account as hydraulic noise spectra of the circulators are essentially narrow band noises with high dominant peaks.

Thus, characterising the acoustic energy of the circulator can only be performed :

- either by using a great number of transducers placed along the pipes, in order to determine the variations of the sound pressure levels, and hence, to estimate a mean value ;
- or by using two transducers in order to determine the acoustic intensity vector with an F.F.T. analyser and a computer [3].

Therefore, we have developed a device called a "Liquid Anechoïc

Terminator" (T.A.L. : Terminaison Anéchoïque pour Liquide), that greatly reduces the stationnary waves. Then, only one transducer is necessary to determine the acoustic energy emitted by the circulator.

Moreover, the circulators being connected to the characteristic impedance of the pipe, measurements do not depend on the test rig. So, it is possible to compare noise spectra of different circulators under the same conditions, by using a test rig made up from a short flexible closed loop.

"LIQUID ANECHOIC TERMINATOR" (T.A.L.) [4]

The "Liquid Anechoïc Terminator" developed by CETIM is a device that highly reduces the stationnary waves into the pipeline connecting the source of excitation to the T.A.L.. The principle of this apparatus is based upon a progressive matching of the pipe impedance from a galvanized pipe to a flexible rubber hose. Patents pending, only the T.A.L. performances will be given.

Results : The following figures clearly show the performance and efficiency of the T.A.L.

Figure 1

Relative phase displacement curves between electric signals of two hydrophone transducers H1 and H2, 24 cm distant.

- dotted line : without T.A.L.
- full line : with T.A.L.
- straight line OA : theoretical line determined in pure progressive wave [5].

Figure 2

Reflection coefficient r versus frequency

- dotted line : without T.A.L.
- full line : with T.A.L.

It is noticed, that beyond 500 Hz, the reflection coefficient is less than 0,1.

Figure 3

Shaded area shows the T.A.L. third-octave band frequency attenuation. Consequently, the T.A.L. acts as a very effective silencer in the frequency range 20 Hz - 10 000 Hz.

TEST RIG FOR CIRCULATOR NOISE MEASUREMENT

A test rig for circulator noise measurement has been designed and developed according to the basic drawing in fig. 4, using the T.A.L.

The equipment under test is placed between two T.A.L., the T.A.L. number 1 acts as a silencer for the valve V, the T.A.L. number 2 acts

as an anechoïc device for the measuring pipe. So, in the rigid measuring pipe only transducer H1 is required for the measurement. Then, a short flexible hose is used to connect the valve V to the T.A.L. number 1. At the top of the rig an expansion chamber fitted with an automatic air-cock is necessary to remove air. Thus, the test rig is operating in a closed loop.

Results : - Figure 5 is an example of the hydraulic noise spectra taken from the two hydrophones H1 and H2. The narrow band analysis has been carried out in the frequency domain 0 - 500 Hz with a 12 Hz bandwith. The spectra are identical, proving the T.A.L. efficiency, whereas without T.A.L., the values of the dominant peaks vary according to the position of the transducers, due to the stationnary waves into the pipe.

The dominant peaks are found at the following frequencies: fr = 40 Hz, rotating speed; and harmonics 2, 3, 4...9 ; N.fr = fp = 280 Hz, blade passage frequency ; fm = 100 Hz magnetic frequency.

Those peaks are characteristic of the nature and the dynamic working of the circulator.

- Figure 6 shows the evolution of the hydraulic noise of 27 circulators (in A weighted values : dBA) as a function of the absorbed power.

CONCLUSION

Numerous experiments have been carried out on different types of circulators and working points. They have shown that the reproductibility and the repetability of measurement are good. So, circulator noise is readily evaluated using a "Liquid Anechoïc Terminator". Due to the results obtained and the low cost of testing, this method will be proposed as a standard.

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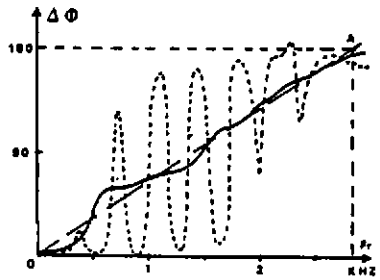

FIGURE 1

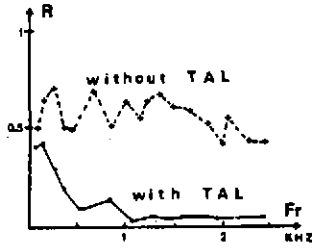

FIGURE 2

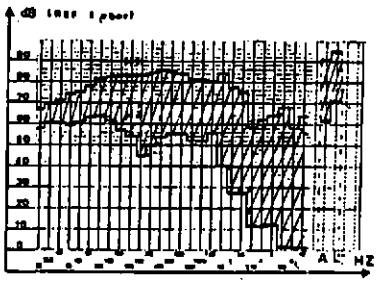

FIGURE 3

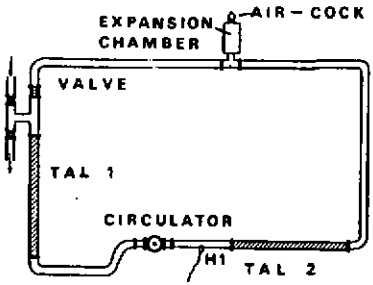

FIGURE 4

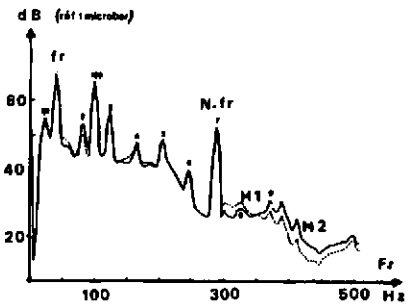

FIGURE 5

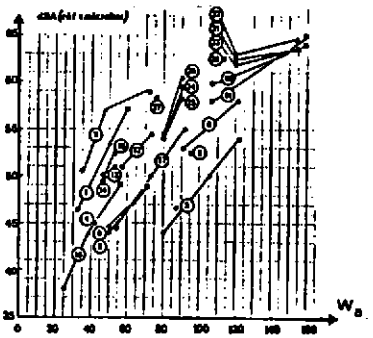

FIGURE 6