Noise test system of rotating machinery in nuclear power station based on microphone array

Xincai Chang *, Jishi Guan and Liangcai Qi
China Nuclear Power Technology Research Institute Beijing Division, Beijing, P.R.China

*Corresponding author e-mail: changxincai@cgnpc.com.cn

Abstract. Rotating machinery plays an important role in all walks of life. Once the equipment fails, equipment maintenance and shutdown will cause great social harm and economic losses. Equipment safety operations at nuclear power stations have always been of top priority. It is prone to noise when the equipment is out of order or aging. Failure to find or develop equipment at the initial stage of equipment failure or ageing will pose a serious threat to the safety of the plant's equipment. In this paper, sound imaging diagnosis technology is applied as a supplementary method to the condition monitoring and diagnosis system of rotating machinery in nuclear power stations. It provides a powerful guarantee for the condition monitoring and fault diagnosis of rotating machinery in nuclear power stations.

1. Introduction

Acoustic source localization is an important branch of passive location technology. The microphone array is used to locate the source of sound, and the source of the sound source is picked up by the multi-channel microphone distributed in the space. The spatial orientation of the sound source is obtained by processing and analyzing the signal of the microphone array [1]. Sound imaging is an important method in the field of sound source localization. It mainly uses microphone array to collect multi-channel acoustic signals in the sound field, reconstructs the sound field near the sound source surface, and predicts the external sound field distribution of the sound source. Through the sound imaging technology, combined with the delay addition algorithm, the current operating state of the equipment can be monitored, and the sound parameters can be collected to obtain the "sound picture" of the equipment [2]. This method does not need to install sensors for vibration signal measurement and analysis, and fully realize non-contact measurement. It can solve the problem of sensor installation in the fault diagnosis of mechanical equipment, and the vibration characteristics are not obvious. Sound imaging technology has a wide range of applications. Can be used to locate the abnormal sound of automobile, household appliances, machine tools, injection molding machines [3], generators [4] and other equipment abnormal sound [5]; sound position or trajectory tracking, such as low altitude UAV warning, shot location, explosion location, trajectory tracking and positioning of bullet, underwater target location [6] and so on.

After studying the design principle of the microphone array, the 6-way high performance silicon analog MEMS microphone WM7121 is arranged in a round array. The MEMS acoustic sensor as the sensor array, different from the traditional electret microphone, digital MEMS acoustic sensor with high
sensitivity, large dynamic range, flat frequency response characteristics of omnidirectional and good consistency, can provide better SNR and anti RF, anti-electromagnetic interference ability.

2. Acoustic imaging test system
A sound imaging test system based on microphone array is designed, which includes the upper system and lower system of communication connection, as shown in figure 1.

![Figure 1. Acoustic imaging test system](image)

The lower system includes a microphone array, for the acquisition of nuclear power station operation of mechanical noise components; pretreatment module for mechanical noise data collected by the microphone array processing; noise positioning module, used for sound source localization of mechanical noise after data preprocessing; and the first communication module, for the sound source localization data output.

The upper system includes second communication module and a first communication module coupling; the main control module is connected with the second communication module for electric, acoustic source localization data communication module second received respectively transmitted to electrically the storage module and display module.

The lower system collects noise accurately through microphone array and determines the location of sound source. The above information is sent to the host computer at the far end to realize the noise detection of the running parts of the nuclear power station.

Because of the microphone array output voltage is relatively small, it is necessary to filter and amplify the data collected. The preprocessing module comprises a filter circuit connected in sequence and an operational amplifier circuit.

3. Noise test of rotating machinery in nuclear power station
Using the acoustic imaging test system, the condensate pump 1# and 2# motor of the steam turbine workshop of the nuclear power station have been tested. When testing the 1#, it was found that the sound curve had an obvious spike near 2KHz, as shown in figure 2.
When testing the 2#, there is no abnormal curve near 2KHz, as shown in figure 3.

The acquisition frequency of the sound imaging test system is set to 1900Hz-2100Hz range, and the sound image acquisition of the two motors is carried out, and the comparison results are shown in figure 4. The 1# motor, we can see that the motor has noise about 2KHz. And the 2# on the right shows no noise in the 2KHz.

The cause analysis indicated that there are two possible sources of noise, one is due to improper installation, and the other one is due to loose parts inside.

4. Conclusion
The above experiments show that it is feasible to apply the acoustic imaging technique to the condition monitoring of rotating machinery in nuclear power stations. In the condition monitoring and diagnosis system of rotating machinery in nuclear power station, it is necessary to introduce sound imaging test
system as a supplementary means to provide a strong guarantee for the condition monitoring and fault
diagnosis of rotating machinery.

References
[1] Brandstein M.S.,Silverman H.A Practical Methodology for Speech Source Localization with
Microphone Arrays,J.Computer Speech and Language,1997,11(2): 91—126.
[2] Hwang S,Park Y,Park Y.Sound Direction Estimation Using Artificial Ear, C.International
Conference on Control, Automation and Systems,Oct.17—20 in COEX,Seoul,Korea,2007.
[3] The space vector PWM control research of a multiphase permanent magnet synchronous, motor for
electrical propulsion. Fei Yu,Xiaofeng Zhang,Huaishu Li,Zhihao Ye. Electrical Machines
and Systems, 2003. ICEMS 2003. Sixth International Conference on . 2003
[4] BJELIC M R, BRKOVIC B, STANOJEVIC M, et al. Fault detection in induction motors using
microphone arrays, C. 2nd International Conference on Electrical, Electronic and Computing
Engineering IcETRAN, 2015.
[5] Tashev, H. Malvar.A New Beamformer Design Algorithm for Microphone Arrays, J.Proceedings
of ICASSP, Philadelphia, PA, USA, March 2005.
[6] ARBERET S,GRIBONVAL R,BIMBOT F.A robust methodto count and locate audio sources in a
multichannel underdeterminedmixture, J. Signal Process,IEEE Transaction on,2010, 58(1): 121-133.