Dynamic mode decomposition of numerical data in natural circulation

E. M. Ramos[1], F. R.T. do Nascimento[2], G. M. Darze[2], J. L. H. Faccini[2], G. A. Giraldi[1]
E-mail: faccini@ien.gov.br

[1] *LNCC,* [2] *SETER-IEN*

Keywords: DMD, natural circulation, numerical data.

Dynamic mode decomposition (DMD) has been used for experimental and numerical data analysis in fluid dynamics. Despite of its advantages, the application of the DMD methodology to investigate the natural circulation in nuclear reactors are very scarce in literature [1], [2]. In this paper it is applied the traditional DMD and its variation, the sparsity-promoting dynamic mode decomposition (SPDMD), for analysis of temperature and velocity fields data, generated by computational simulation of an experimental setup in reduced scale, similar to a heat removal system by natural circulation of a pool-type research reactor. The experimental setup is shown in Fig. 1. It was designed according to similarity criteria for scaling reduced models in relation to a prototype of a pool type 30 MW research reactor.

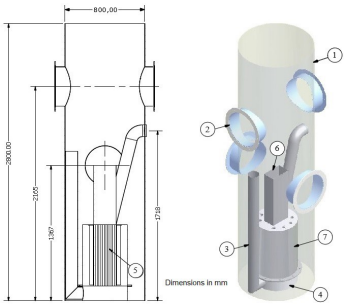

Fig. 1. Experimental setup: vessel (1), viewfinder (2), NC tube (3), plenum (4), electrical resistances (5), chimney (6), and reflector (7).

Firstly the numerical data is partitioned, using a space-time correlation approach, in order to identify fundamental sequences to compute the dynamic modes. Next, the DMD and SPDMD methodologies are applied over each subsequence to obtain the dynamic modes of the temperature and velocity fields. Finally the flow fields are reconstructed and compared with the original numerical data. The conclusion is that the SPDMD performs better than DMD to represent both the temperature and velocity data although the visual comparison does not show significant differences, as observed in Figs 2-3.

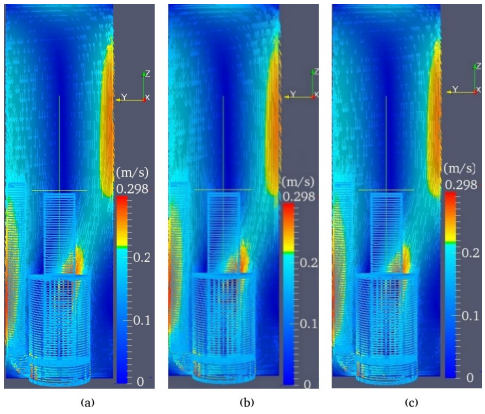

Fig. 2. (a) Visualization of the velocity field at simulation time 16, 077 seconds. (b) Same numerical frame reconstructed using DMD. (c) Reconstruction using SPDMD dynamic modes.

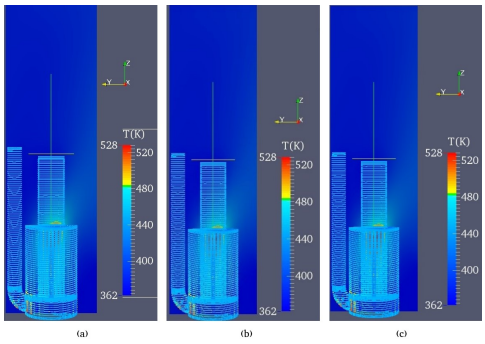

Fig. 3. (a) Temperature field at simulation time 16, 077 seconds. (b) Reconstruction using DMD. (c) Reconstruction using SPDMD dynamic modes.

References

[1] RAMOS, E. M; NASCIMENTO, F. R. T; DARZE, G. M.; FACCINI, J. L. H.; GIRALDI, G.A. Dynamic mode decomposition of numerical data in natural circulation, Brazilian Journal of Radiation Sciences 08-03A, 01-18 (2020).

[2] SCHMID, P. J. Dynamic mode decomposition of numerical and experimental data, Journal of Fluid Mechanics, 656, 5–28, (2010).