

Study of methods for the resolution of large sparse linear systems associated with multiphase flow tomography problem

Jonas L. Ansoni*

Instituto de Ciências Matemáticas e de Computação, ICMC, USP
Av. Trabalhador São-carlense 400, 13560-970, São Carlos, SP
E-mail: laerte@grad.icmc.usp.br

Analice C. Brandi

Grazieli L. C. Carosio

Paulo Seleglim Jr.

Núcleo de Engenharia Térmica e Fluidos, EESC, USP

Av. Trabalhador São-carlense 400, 13566-970, São Carlos, SP

E-mail: analice@sc.usp.br,

grazieli@sc.usp.br,

seleglim@sc.usp.br

ABSTRACT

This work presents a contribution to the development of a specialized method to solve the linear system associated with tomography problem. According to the literature ([1] and [3]), the computational performance obtained is still insufficient for the application in practical engineering problems. Multiphase flow tomography problems involve the solution of a large linear system, whose matrix obtained from the discretization in finite elements is sparse, symmetrical and positive-definite, requiring equally high computational effort in both storage and resolution. The storage of the sparse matrix occupying a minimum space of memory and the solution of the linear system consuming the lowest possible time must provide a high efficiency in the tomography problem resolution. Specifically, the singular value decomposition method (SVD – direct method) [4] and the preconditioned biconjugate gradient method (PBCG – iterative method) [6] were studied with regard to the features of the matrix problem and computational performance. Two types of problem were studied: the reconstruction of the convection coefficient by non-intrusive thermal sensing (applying a heat flux at the external boundary and measuring the response temperatures) [2] and the reconstruction of the fluid's permittivity distribution by non-intrusive electrical sensing (applying a voltage distribution at the external boundary and measuring the response currents) [5]. In both cases, the results showed that the PBCG method obtained a higher computational performance in comparison with the SVD method. More specifically, the PBCG method is faster in obtaining the solution and demands

considerable fewer memory storage. On the other hand, the SVD method is capable of obtaining the solution even if problem matrix becomes ill-conditioned.

References

- [1] L. Borcea, Electrical impedance tomography, *Inverse Problems*, vol. 18, pp. R99-R136 (2003).
- [2] G. P. de Campos, Contribuição ao desenvolvimento de visualização térmica para monitoração de processos envolvendo fluidos multifásicos, Tese (Doutorado) - EESC, Universidade de São Paulo, São Carlos (2004).
- [3] M. J. Colaço, H. R. B. Orlande and G. S. Dulikravich, Inverse and optimization problems in heat transfer, *J. of the Braz. Soc. of Mech. Sci & Eng.*, vol. 28, No. 1, pp. 1-24 (2006).
- [4] G. H. Golub and C. F. Van Loan, "Matrix Computations", The Johns Hopkins University Press, 2nd edition, 1993.
- [5] V. P. Rolnik and P. Seleglim Jr, A specialized genetic algorithm for the electrical impedance tomography of two-phase flows, *J. of the Braz. Soc. of Mech. Sci and Eng.*, vol. 28, No. 4, pp. 378-390 (2006).
- [6] Y. Saad, "Iterative Methods for Sparse Linear Systems", SIAM, 2nd edition, 2003.

* bolsista de Iniciação Científica FAPESP