ONE-WAY FSI ANALYSIS FOR HIGH-PERFORMANCE BLADE DESIGN WITH OPEN-SOURCE PARALLEL FEM SOFTWARE FRONTISTR

Gaku Hashimoto* , Hiroshi Okuda* , Tadashi Tanuma , Yoshinari Fukui*** , Naoki Shibukawa**** and Kenichi Okuno******

***Graduate School of Frontier Sciences, The University of Tokyo**
****Applied Fluid Dynamics & Energy Machinery Systems, Joint Program Center, Teikyo University**
*****Japan Agency for Marine-Earth Science and Technology**
******Power and Industrial Systems Research and Development Center, Toshiba Corporation**

ABSTRACT

In this presentation, one-way fluid-structure interaction (FSI) analysis of rotor blades is shown with FrontISTR (**) which is an open-source parallel finite element method (FEM) software. This software has various functions of linear/nonlinear static structural analysis, linear/nonlinear dynamic structural analysis, engine value analysis, steady/unsteady heat transfer analysis, etc. Program implementation of each function is based on a sparse linear solver. As the linear solver, the iterative method and the direct method are available. In parallel computing, the FrontISTR program corresponds to distributed memory environment and message passing interface (MPI) is used as a communication library.

We deal with rotor blades at the last stage of a steam turbine. High-accurate rotor blade analysis realizes the development of high-performance blades and leads to increase of turbine efficiency. The Earth Simulator of Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is utilized as massively parallel computers in this study.

First, we analyze engine values of the rotor blades which are imposed by only centrifugal force and compare the numerical results with measured data in an actual operating steam turbine. In this analysis, blade-wire contact conditions are approximated as connection of the nearest two nodes by the multi-point constraint (MPC) conditions. It is confirmed that the validity of this rotor blade analysis model.

Second, we implement one-way FSI analysis of rotor blades imposed by oscillatory aerodynamic force and centrifugal force. The aerodynamic force is computed by an in-house computational fluid dynamics (CFD) software and saved in a file at selected time steps. The rotor blade model is then analyzed with the aerodynamic force input from the file. It is confirmed that structural

frequency modes obtained by the fast Fourier transform (FFT) include high frequency modes of the flow around the blades.

As a future plan, we will use iterative computing of two-way coupling with the FrontISTR and the in-house CFD software and investigate vibration stress caused by ununiform circumferential flow.

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