A NEW UNSTEADY FLUID NETWORK APPROACH TO SIMULATE THE CHARACTERISTICS OF THE AIR SYSTEM OF A GAS TURBINE SYSTEM

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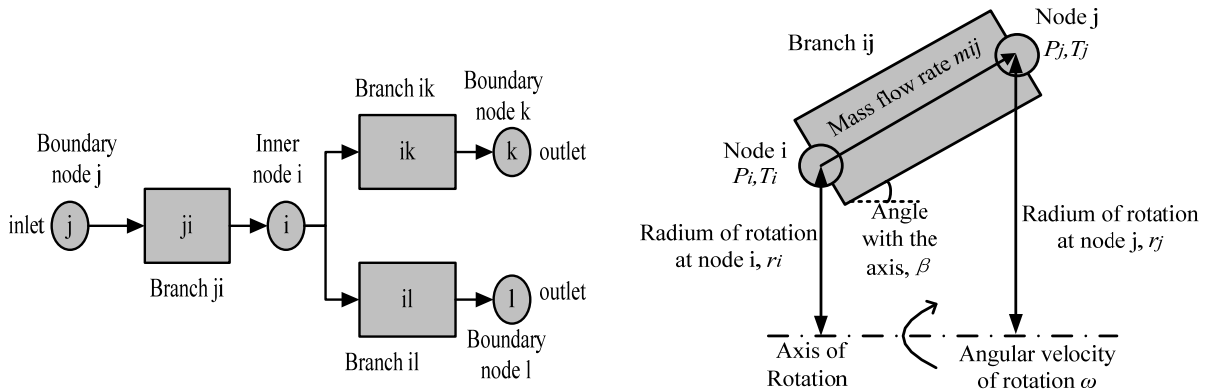
ABSTRACT. In this paper, a novel unsteady fluid network simulation method to compute the air system of jet engine was coded to predict the characteristics of pressure, temperature and mass flow rate of the flow and the temperature of the solid in the gas turbine engine. The fluid and solid areas are divided into the network comprised of branches and nodes, and the method solves transient mass, energy conservation equations at each node and momentum conservation equation at each branch by a newly deduced numerical method. With this method, to simulate complicated fluid and solid system in short time becomes possible. To verify the code developed, it has been applied to simulate a gas turbine model against the widely used commercial software FlowMaster. And the comparisons show that the two are in good agreement. Then the verified program is applied to the prediction of the characteristics of a designed turbine disk and air-cooling system associated to it, and useful information is obtained.

FLUID NETWORK MODEL AND SIMULATION PROCEDURE

Fluid Network Model In the simulation, the fluid and solid systems are simplified into networks (see Figure 1) which comprised of boundary nodes j, k, l, internal node i, and branches ji, ik, il. The mass conservation equations, energy conservation equations and species conservation equations are set up at nodes and the momentum equations are set up at the branches.



(a) (b)

Figure 1. Schematic drawing of fluid network and basic unit: (a) fluid network and (b) basic unit

Solid-fluid Boundary disposal The solid area and fluid area are connected with the convection heat transfer branches, and along the flow direction, the solid nodes along the fluid branch are connected to the outlet node of this branch.

Procedure Figure 2 shows the process flow diagram. The momentum and energy conservation equation are coupled and the mutual effect of momentum and energy is achieved through iterative computation.

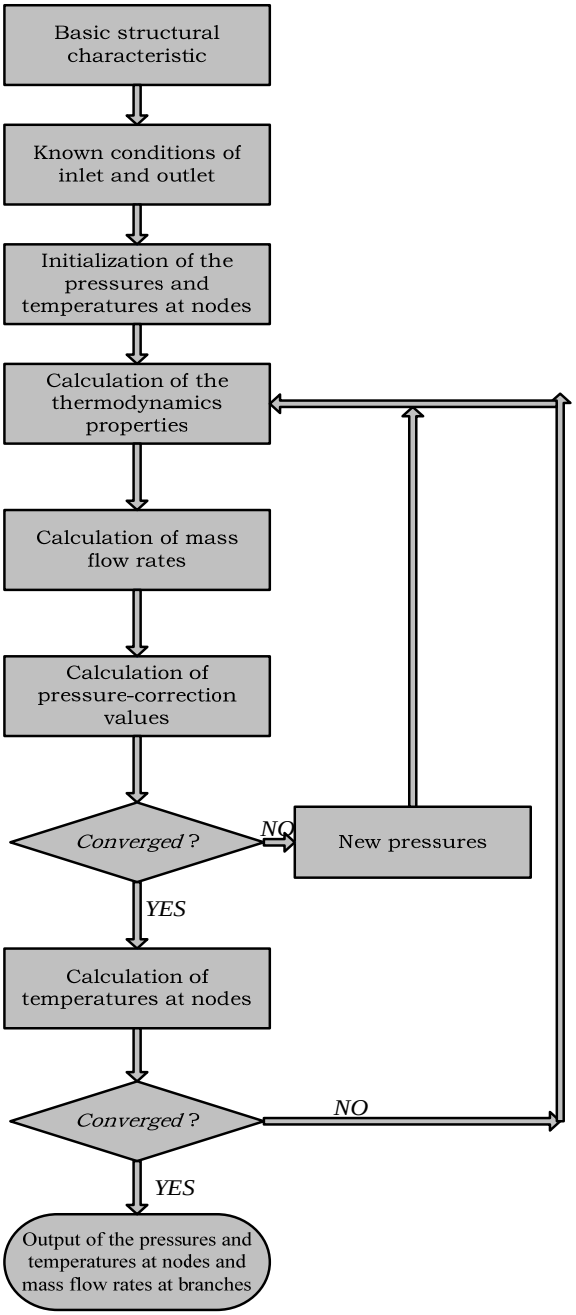


Figure 2. Flowchart of calculation at each time step

VERIFIED EXAMPLE

The feasibility of the proposed method is demonstrated with the model which has been predicted by the widely used software Flowmaster, more details can be found from Flowmaster Inc. [2007]. Fig 3 shows the comparisons between the code and Flowmaster. The comparisons show good agreements.

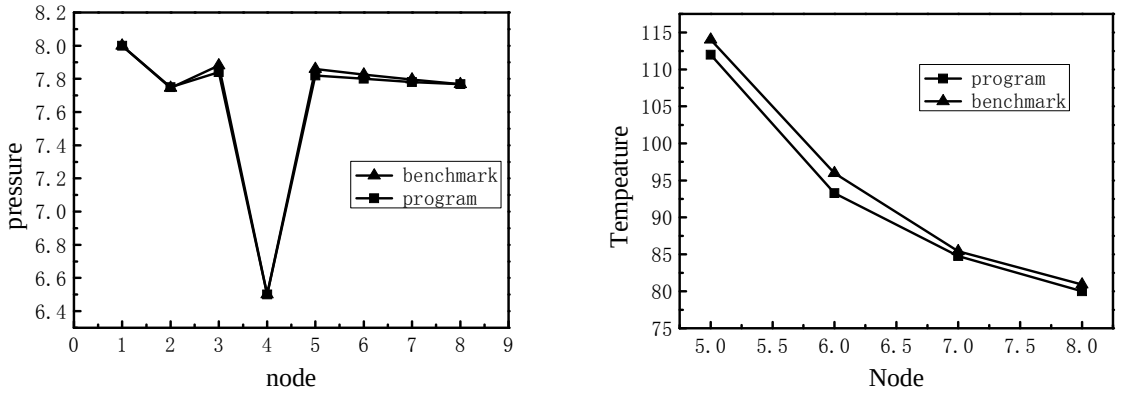


Fig 3. Comparisons of the predicted parameters

APPLICATION OF PROGRAM TO THE TURBINE RESEARCH

The program is applied to simulate a turbine disk. Fig 4 shows the model and the network division.

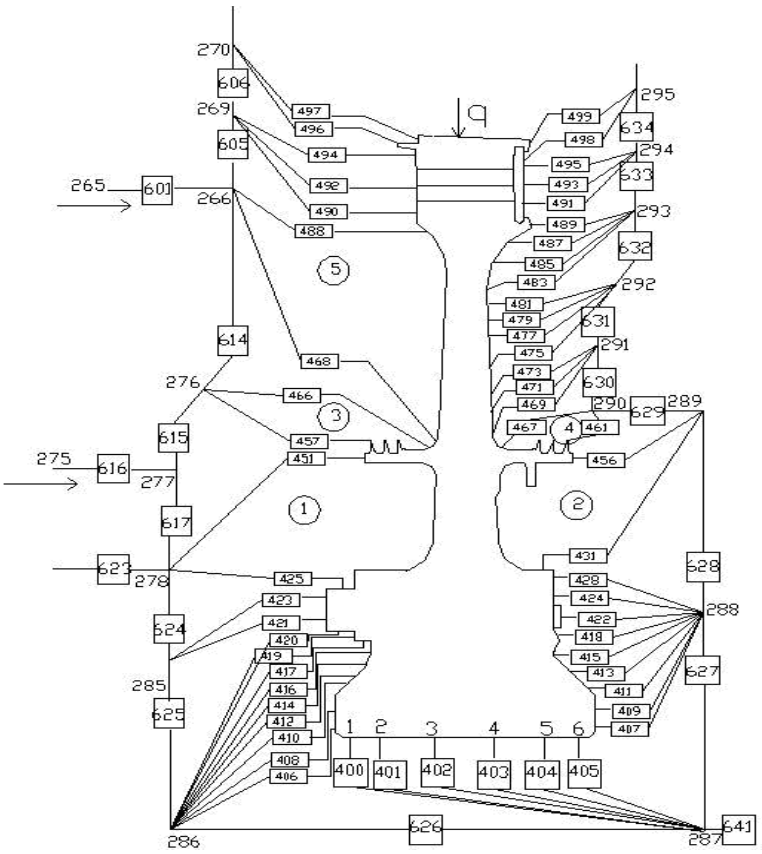


Fig 4. Network model of turbine disk

Figure 5 shows the simulation results, including the steady and transient characteristics of turbine, which provide useful information for the evaluation and the modification of turbine disk.

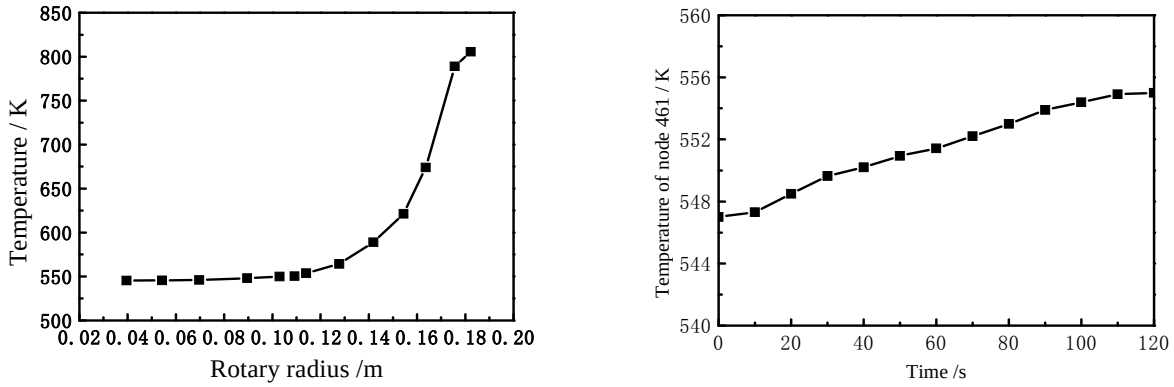


Fig 5. Predicted steady and transient results

CONCLUSION

A newly developed computational algorithm for the unsteady solid and fluid network system simulation is proposed, which makes the simulation of complicated fluid and solid system efficient. The feasibility of the proposed method is verified by being applied into the model which has been computed by Flowmaster Inc. The verified code is then applied into turbine disk research to simulate the steady and transient characteristics of the cooling air and the turbine disk which provides useful information for the design, evaluation and modification of the jet engine.

REFERENCES

Flowmaster Inc. [2007], *Flowmaster V7-New User Training Version 10*, pp.73-80.