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NUMERICAL INVESTIGATION ON SURFACE ROUGHNESS EFFECT OF SAND EROSION PHENOMENA IN 90 DEGREE BEND

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ABSTRACT

Sand erosion is a phenomenon where solid particles impinging to a wall cause serious mechanical damages to the wall surface. This phenomenon is a typical gas-particle two-phase turbulent flow and a multi-physics problem where the flow field, particle trajectory and wall deformation interact with among others. It is well-known that the performance and lifetime of various machines, such as airplane, ship, gas turbine, pump and so on, are severely degraded due to sand erosion.

In recent years, sand erosion phenomenon has been simulated numerically to protect industrial machines from the mechanical damage. In these simulations, however, the change of the flow field and the relating particle trajectory during the erosion process were not taken into account. This treatment is physically unrealistic. Hence, we have developed the numerical procedure for sand erosion phenomenon, including the temporal change of the flow field and the wall shape [1]. To simulate the phenomenon, the turbulent flow field, the particle trajectory and the amount of erosion on the eroded wall are calculated repeatedly. The computational grid consists of flow field region and also inner wall region. According to the change of wall shape, the computational grid nodes are treated as those in flow field or wall (see Fig. 1).

On the other hand, the erosion of a surface by solid particles in a fluid stream is perhaps the dominant factor which makes industry reluctant to install pneumatic conveying systems for handling abrasive materials [2]. Erosion is severer for sudden changes in the flow direction, for example, bends, cyclones and valves of conveying systems. The bend erosion is typical target of sand erosion experiments and is useful for verification of numerical simulations.

In our previous study, we verified some linear and nonlinear RANS turbulence models to predict sand erosion phenomena in a square-section 90 degree bend [3]. Our numerical results are in good agreement with the experimental data of a 90 degree bend flow by Kim and Patel [4] and with observation of sand erosion by Mason and Smith [2]. Figure 2 shows the comparison of the predicted erosion depth, and Fig. 3 is the development of eroded surface geometry.

In our method, the change of a wall shape is resolved by a computational grid.

Therefore, this model cannot reproduce a micro-scale surface roughness smaller than the grid size. If a low-Reynolds-number (LRN) turbulence models are adopted, the effect of surface roughness is fully resolved, because the scale of such a fine grid required by a LRN model is smaller than the fluid-dynamically ignorable roughness element height. However, we did not make sure that the effect of a wall surface roughness is accurately reproduced in the cases with a high-Reynolds-number (HRN) model. Thus, we use a wall function for a rough surface to consider the small scale roughness in this work.

In the present study, we apply our sand erosion prediction code to a 90 degree bend. Then, we use a LRN model, HRN model with a wall function for smooth surface and HRN model with a wall function for a rough surface, and investigate the influence of such wall surface treatments.

REFERENCES

[1] J. Kuki, K. Toda and M. Yamamoto, "Development of numerical code to predict three-dimensional sand erosion phenomena", *Proc. ASME FEDSM 2003*, FEDSM2003-45017, (2003).

[2] J. S. Mason and B. V. Smith, "The erosion of bends by pneumatically conveyed suspensions of abrasive particles", *Powder technology*, Vol. 6, pp. 323–335, (1972).

[3] M. Suzuki, K. Inaba and M. Yamamoto, "Numerical simulation of sand erosion phenomena in square-section 90 degree bend with linear/nonlinear RANS turbulence models", *Proc. ASME FEDSM 2007*, FEDSM2007-37030, (2003).

[4] W. J. Kim and V. C. Patel, "Origin and decay of longitudinal vortices developing in a curved rectangular duct", *ASME Journal of fluids engineering*, Vol. 116, 1, pp. 45–51, (1994).

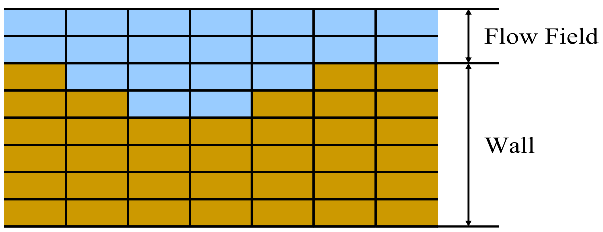


Fig. 1 Schematic of computational grid

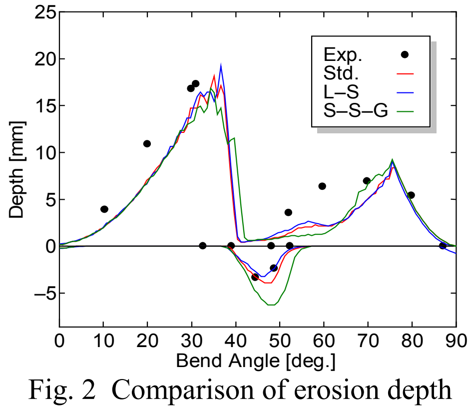
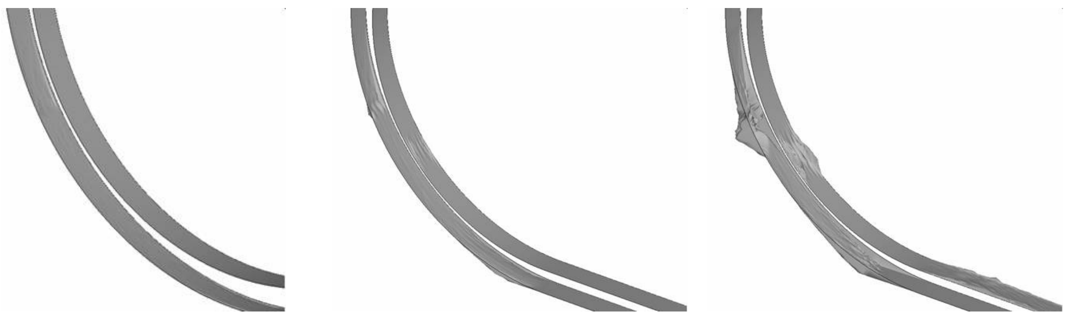


Fig. 2 Comparison of erosion depth



(a) 20% sand ingestion (b) 40% sand ingestion (c) 100% sand ingestion

Fig. 3 Development of eroded surface in 90 degree bend