Comparison of PD method and FEM method on simulating the failure process for thin-wall steel cylinder under quasi-static uniaxial tensile loading

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ABSTRACT

The Peri Dynamic(PD) is a kind of novel method based on particle description for solid entities developed by S.A. Silling. The constitutive formulation in traditional continuum mechanics description were replaced by the force functions between Peri particles. After Kilic developed a micro-elastic force function for PD model and discussed its consistency with the constitutive formulation in continuum mechanics, the PD method were applied in some engineering practices. The PD simulation on high-speed impacting problems did improve the understanding for certain phenomenon. The potential for PD method on quasi-static problems is still not discussed in detail.

The FEM method is a dominant method in engineering mechanics simulations. It is widely used in simulations for all sorts of mechanical problems and there are a number of commercial codes or open source codes. They are all facing same difficulties when failure process is interested in. The spatial partial derivatives are hard to deal with when a fracture or a crack is nearby. The conservation of mass is hard to maintain when elements were deleted for they are considered as damaged according to specified criterions. The criterions themselves are difficult to choose and the parameters of them are hard to determine.

Here the comparison of the PD method and the FEM method on simulating the failure process for thin-wall steel cylinder under quasi-static uniaxial tensile loading were carried out. Along with the comparison, a special criterion for damage of PD particle based on geometrical compatibility was discussed.

The PD method is natural for problems with the damage phenomenon of materials considered. There is no spatial partial derivative in the whole computational process so there is no such sort of difficult as in FEM simulations. No PD particle would be removed during the simulation so the conservation of mass is perfectly kept. The widely used criterions for the damage situation of PD particles are directly perceived through the senses. There are criterions based on the average distance between neighbor PD particles, or on the minimum distance between neighbor PD particles, etc. A special criterion based on geometrical compatibility was discussed here, the damage situation of PD particles is determined by the strain field obtained from the PD model.

The numerical example discussed here is a thin-wall steel cylinder under quasi-static uniaxial tensile loading, and the failure process is interested in. Before the cracks emerging, the difference between the simulation results obtained by the PD and the FEM method is in the error range of calculations. When there are damaged areas in the cylinder, the results obtained by FEM method is highly depended on the damage criterion and its parameters, while the results obtained by PD method show clear patterns of damage areas. The patterns are not affected much by the damage criterions, although the damage criterions do help to understand the failure process. The computational burden of the PD model is heavier than the FEM method before the damage of material begins. But after that, the computational burden of these two methods is not significantly different.

REFERENCES