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# GPU High Performance Explicit Solution for Kinematics and Dynamics Simulation of Crank-connecting Rod-piston Mechanism

**Zhaosong. Ma[1]*, Dong. Zhou[1] and Zhigang. Li[1]**

[1] Institute of mechanics, Chinese academy of sciences, No.15 Beisihuanxi Road, Beijing, China(100190), marze@163.com

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Using finite element method for kinematics and dynamics simulation of mechanism is time consuming because of the great number of time steps. For a typical crank-connecting rod-piston mechanism, an analysis period may achieve up to hundreds to thousands of seconds, and for explicit method the stable time step may be as small as $10^{-5}$sec. Although the implicit method is unconditionally stable and thus may help reducing the number of time steps, it requires solving linear equations for every time step. To improve the performance of the calculation, a GPU computing algorithm is used which is developed based on the Continuous-based Discrete Element Method[1][2], on which the explicit scheme is applied. To solve large rotation, the incremental finite element approach is used, the node coordinates and the stiffness matrices have to be updated and reconstructed for each iteration.

The mechanism to be analyzed is an air compressor, as shown in Figure 1, which consists of a crankshaft, 6 cylinders with pistons in it, and rods connecting the pistons and the crankshaft. Two models, respectively a 196,394 tetrahedron elements mesh, and a 399,222 tetrahedron elements mesh system are established and analyzed. The linkage of the parts is implemented by forcing coaxes of the rods and the crankshaft, and coaxes of the pistons and the rods. Working pressure is applied on the end faces of the pistons, and angular velocity is applied on the input end of the crankshaft.

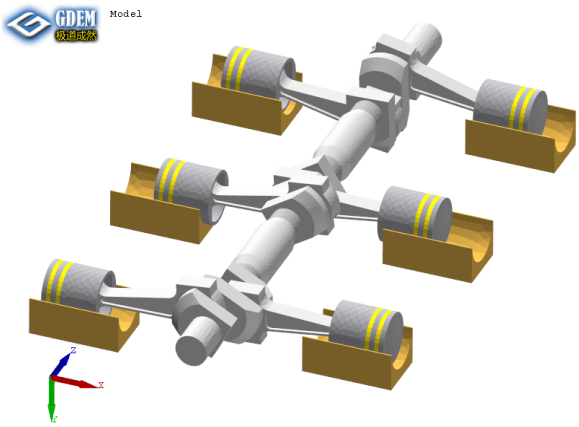


Figure 1

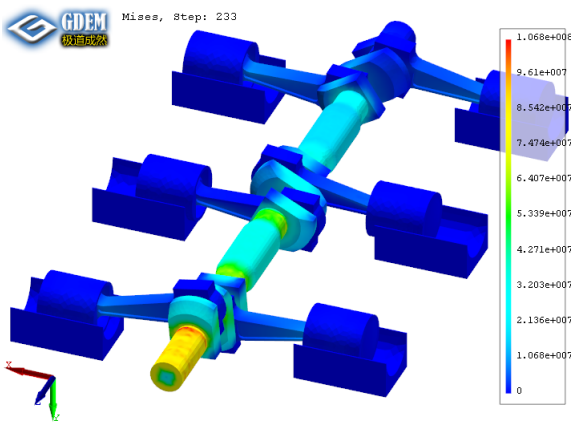


Figure 2

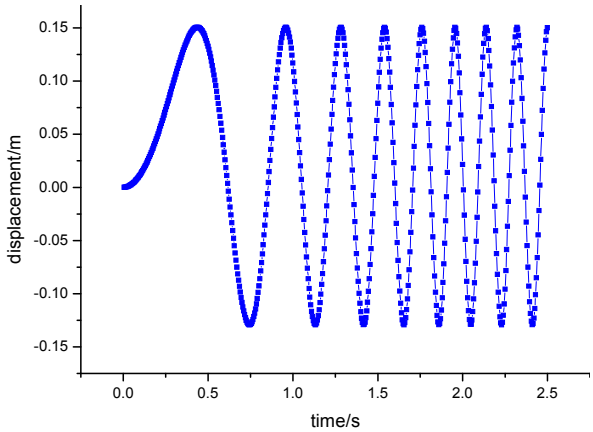


Figure 3

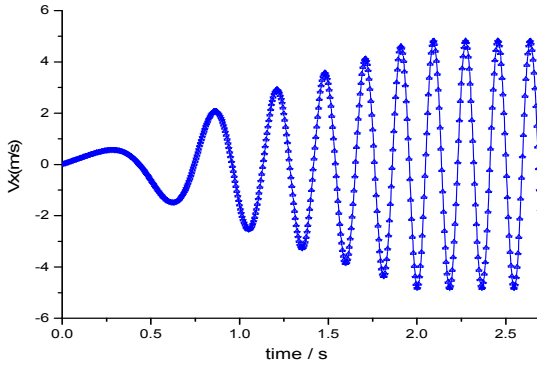


Figure 4

The GPU computing system is a laptop computer with an Intel I7-4770 CPU and a NVIDIA GTX Titan GPU, 32GB system memory, 6GB video memory. The execution performance achieves 73 million elements*steps per second. For most of the models and working conditions, the program finishes within one hour. The results include mechanism motion videos, stress nephograms(Figure 2), accelerations and velocities of monitoring points(Figure 3, Figure 4), which show the entire process including elastic wave propagation, the mechanism vibration and the motion.

## REFERENCES

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