Influence of Different Immersion Depth on Shear Stress

Shixu Li [a], Liang Li, Jiefeng Mou, Huimin Sun, Jie Wei, Nannan Liu

College of Mechanical and Electronic Engineering, Shandong University of Science and Technology, Qingdao, 266590, China;

[a]1258351314@qq.com

Abstract

Magnetorheological finishing(MRF) is a new advanced optical manufacturing technology in recent decades.The principle of magnetorheological finishing is this: in the magnetic field, the occurrence of rheological MR fluid flow through the workpiece and the movement of the small gap formed by the workpiece surface contact with the area to produce a large shear stress, so that the workpiece surface material is removed.In this paper, the size of CeO2 under different invasion depth is simulated by simulation.

Keywords

Magnetorheological finishing; shear stress; invasion depth; simulation.

1. Introduction

In the intelligent material, the magnetorheological fluid (MR fluid) due to its specific magneto-rheological effect and get a wide range of attention[1]. MR fluid is a suspension of micron-sized magnetic particles and non-magnetic liquids (mineral oil, silicone oil, etc.)[2-3]. The rheological properties of the MR fluid change in the change of the magnetic field. It reveals non-Newtonian rheological behavior without a magnetic field. Its microstructure and macroscopic mechanical behavior will change significantly, and in the external magnetic field has a certain shear yield stress [4]. MR fluid has the advantages of controllable, rapid and reversible, which is widely used in the fields of vehicle, building structure, medical equipment, sports equipment, finishing and sealing of precision materials [5-6].

2. Magnetorheological finishing mechanism

The process of Magnetorheological finishing is in accordance with Bingham model [7].The equation for the Bingham model is

$$\begin{cases} \tau = \tau_y(B) + \eta\dot{\gamma} & \tau \geq \tau_y(B) \\ \dot{\gamma} = 0 & \tau < \tau_y(B) \end{cases}$$

Where B is magnetic induction density of magnetic field and $\tau_y(B)$ is yield stress induced by magnetic field, η is viscosity of MR fluids and $\dot{\gamma}$ is shear rate.

2.1 Preprocessing

The use of CeO2 as ab rasive, the silicon surface material removal.Among them, the ball diameter of 0.16mm, spherical distance from the silicon plane were 0.45mm, 0.43mm, 0.42mm, while the convex surface of the bottom radius of 0.1mm, 0.5mm high.As the Fig. 2.1.1, Fig. 2.1.2, Fig. 2.1.3 shows.

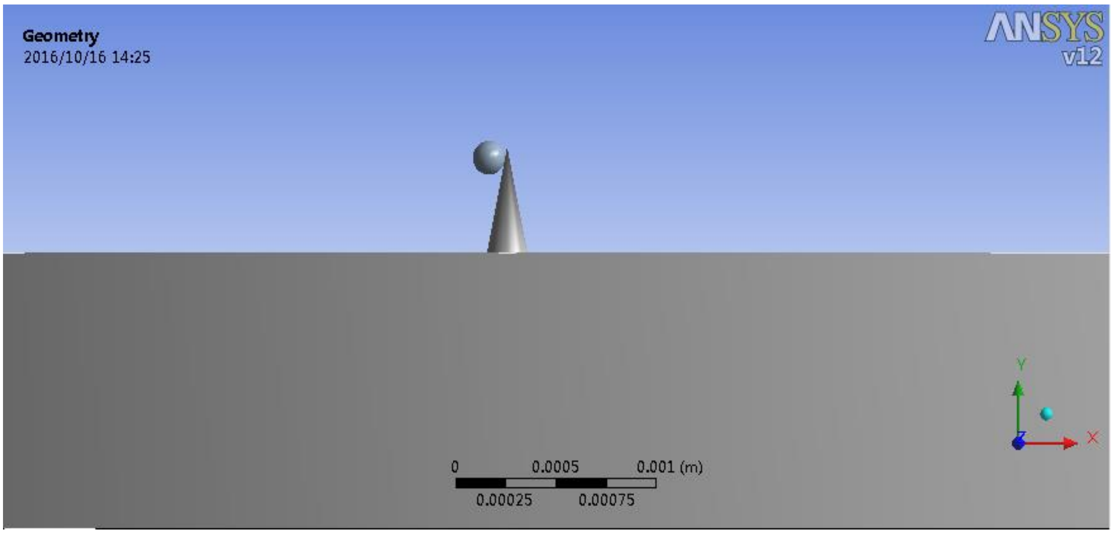


Fig. 2.1.1

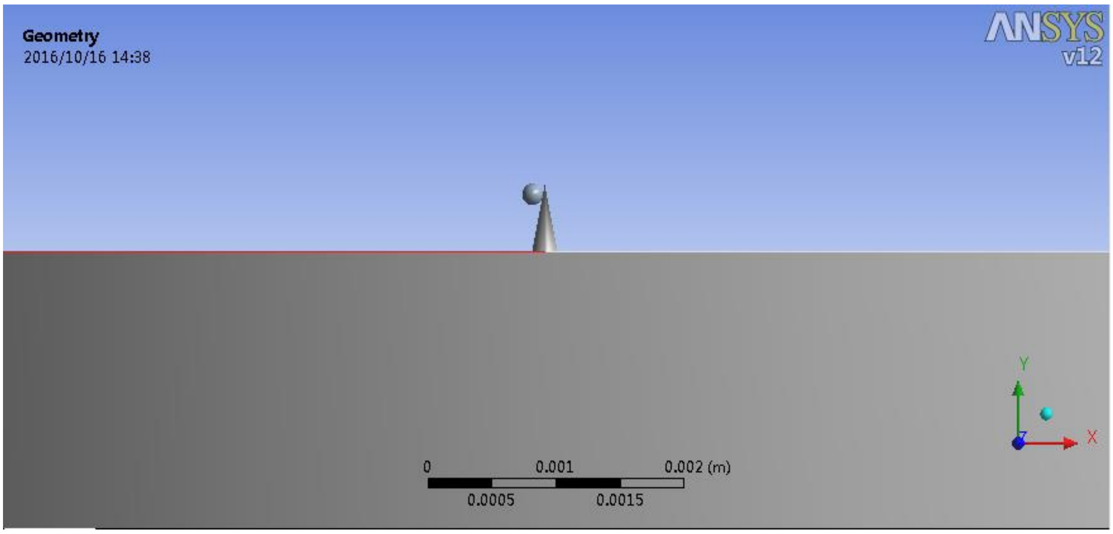


Fig. 2.1.2

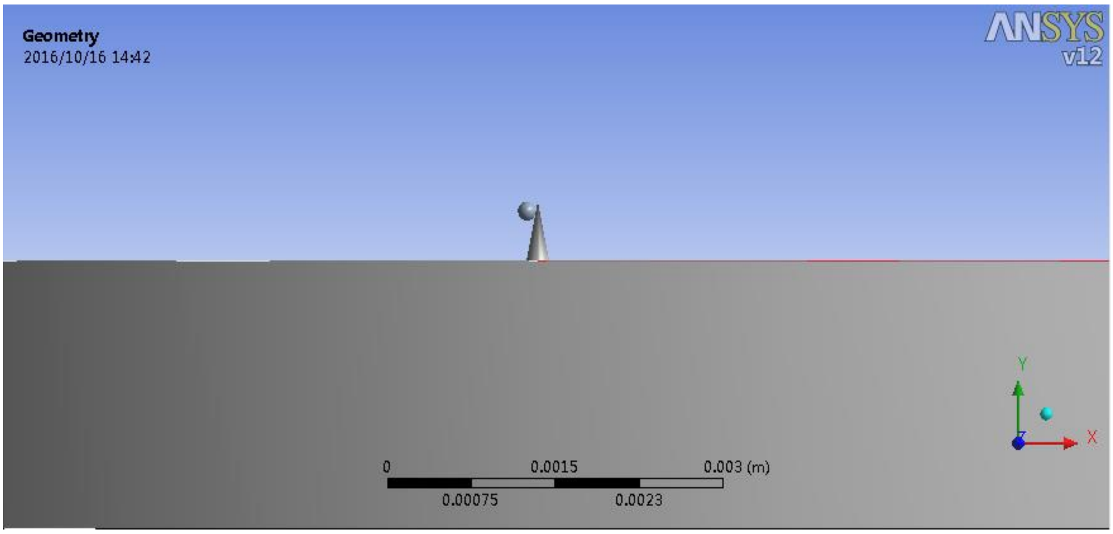


Fig. 2.1.3

And then meshing, get the following Fig. 2.1.4, Fig. 2.1.5, Fig. 2.1.6.

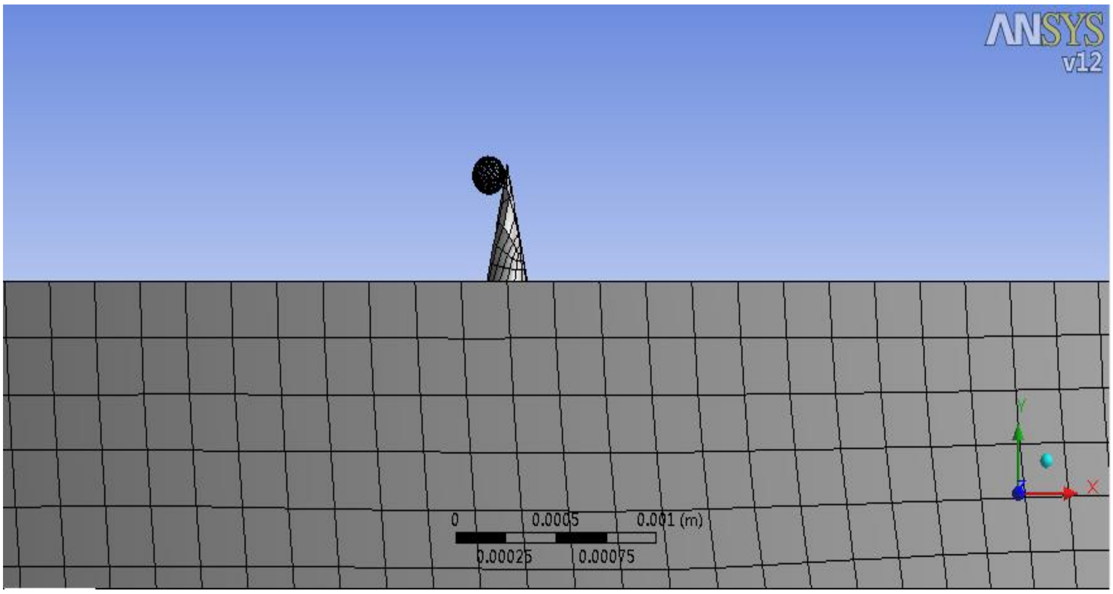


Fig. 2.1.4

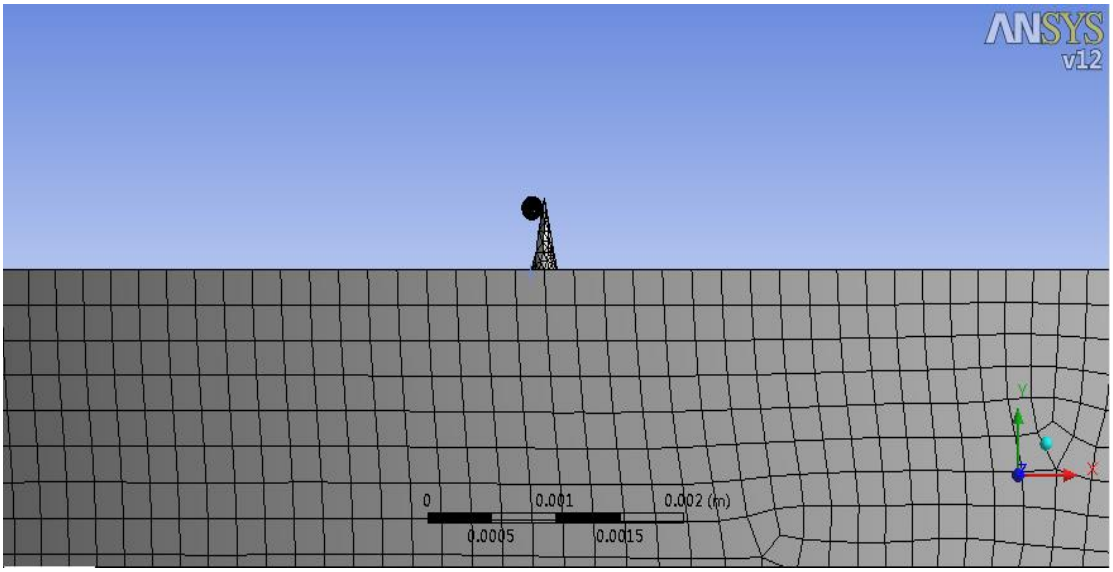


Fig. 2.1.5

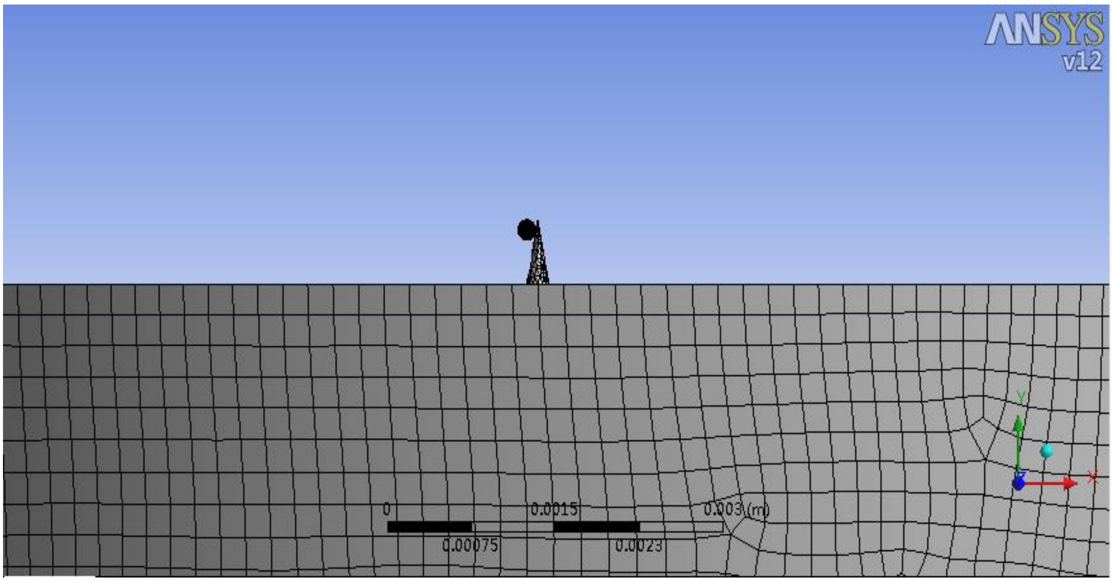


Fig. 2.1.6

2.2 Constraint

Due to the influence of the immersion depth on the material removal stress, three identical velocities were set for the study. In the process of material removal, the cerium oxide particles are subjected to three forces, namely: (1), the pressure, from the surrounding carbonyl iron powder particles in the magnetic field in the magnetic field of the force and fluid dynamic pressure. (2), shear stress, from the magnetorheological fluid power. (3), resistance, from the abrasive and the workpiece surface contact, friction. Therefore, given the silicon surface fixed constraints, as shown, given cerium oxide abrasive a certain level of speed and vertical velocity and tanα≈0.1667.As shown in Fig. 2.2.1, Fig. 2.2.2, Fig. 2.2.3.

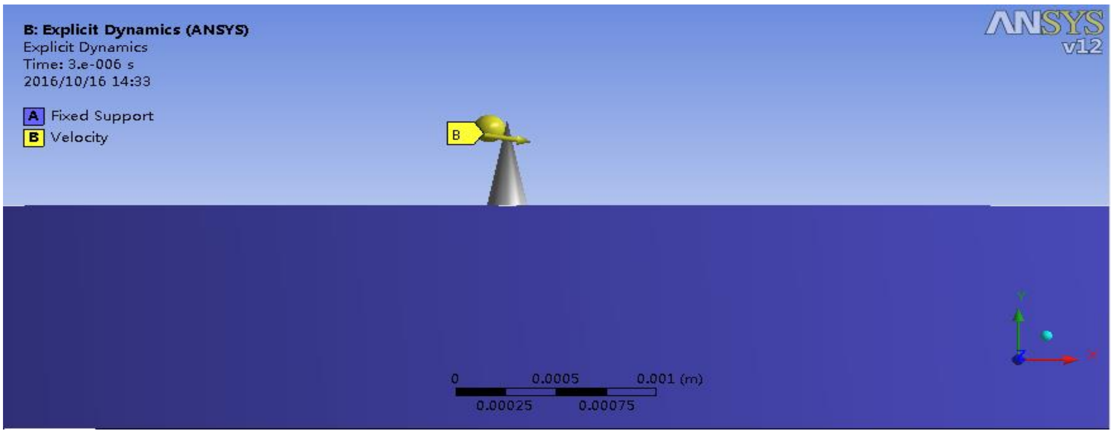


Fig. 2.2.1

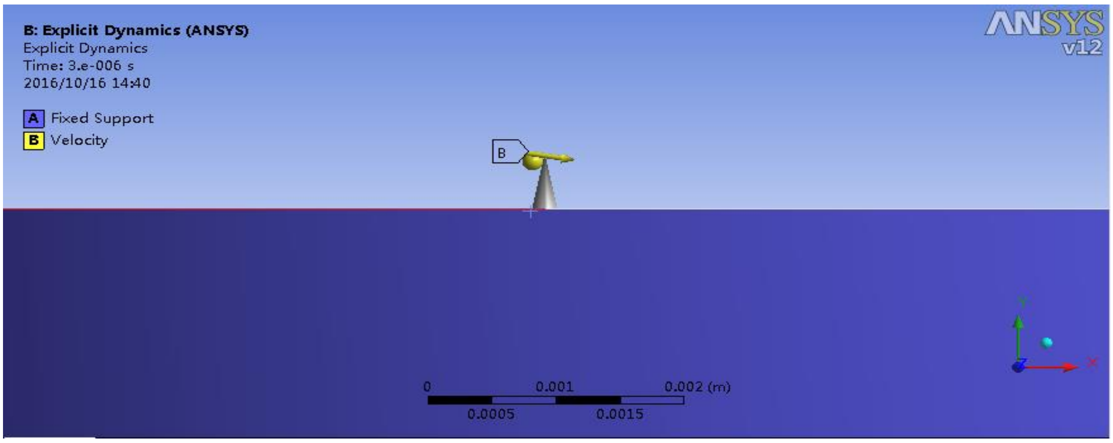


Fig. 2.2.2

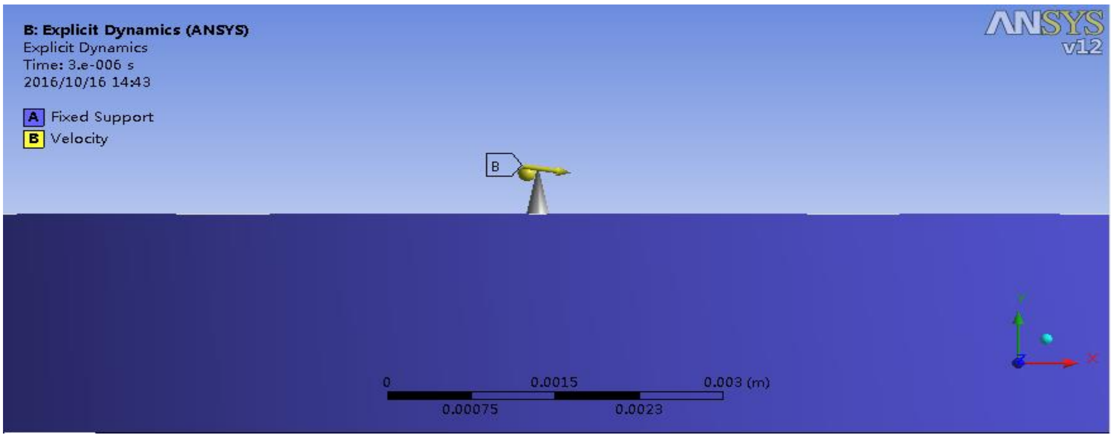
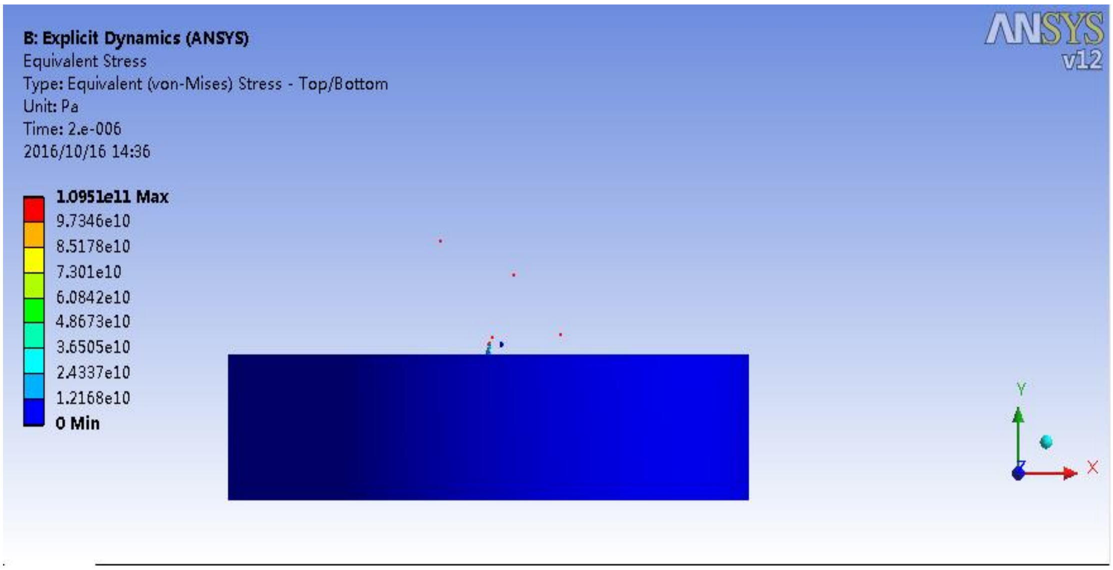


Fig. 2.2.3

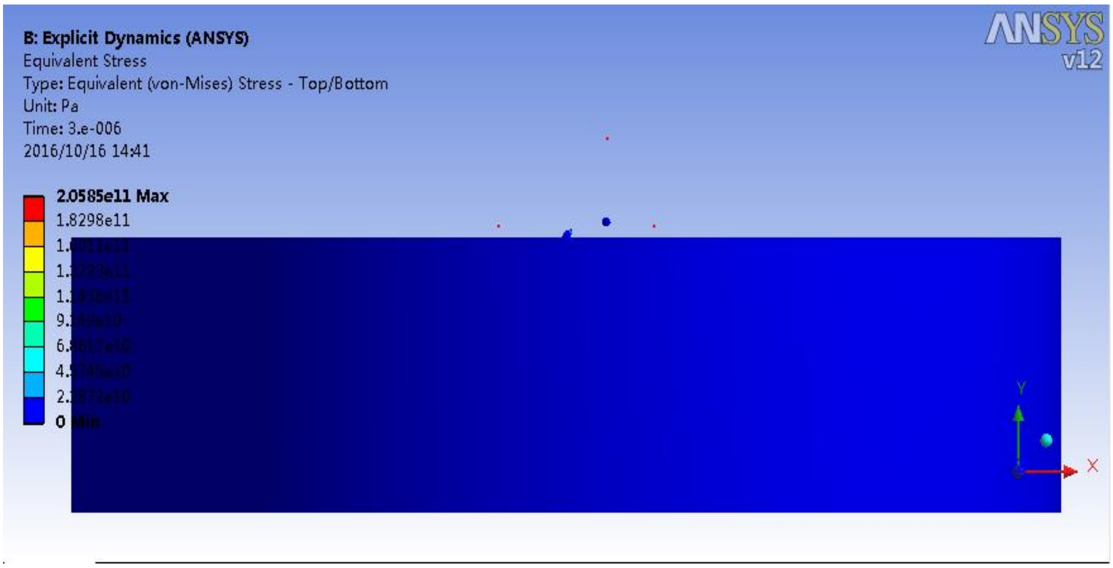
2.3 Post-processing

The following results are obtained which show in Fig. 2.3.1, Fig. 2.3.2, Fig.2.3.3 by solving the problem.



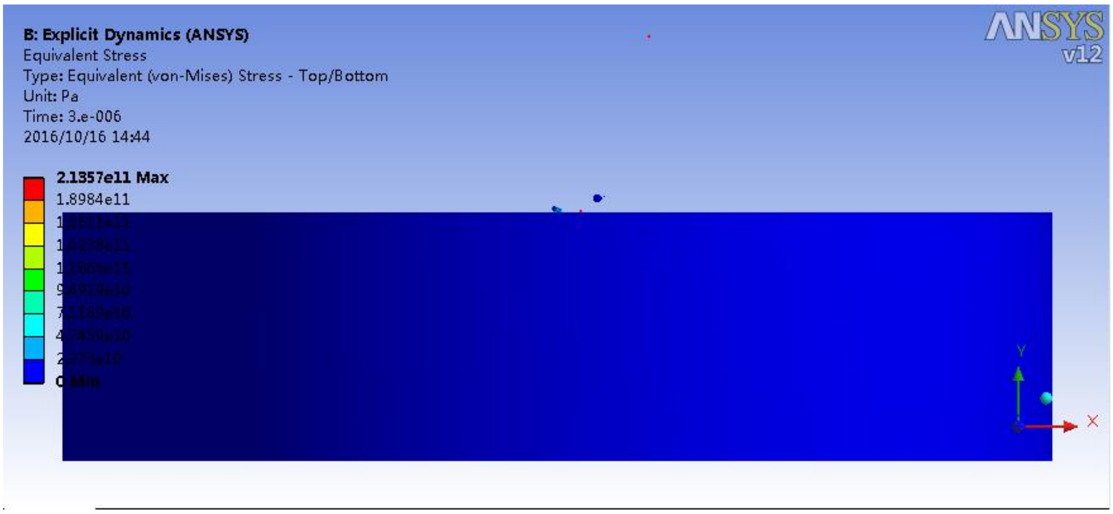
B: Explicit Dynamics (ANSYS)
Equivalent Stress
Type: Equivalent (von-Mises) Stress - Top/Bottom
Unit: Pa
Time: 2.e-006
2016/10/16 14:36

Fig. 2.3.1



B: Explicit Dynamics (ANSYS)
Equivalent Stress
Type: Equivalent (von-Mises) Stress - Top/Bottom
Unit: Pa
Time: 3.e-006
2016/10/16 14:41

Fig. 2.3.2



B: Explicit Dynamics (ANSYS)
Equivalent Stress
Type: Equivalent (von-Mises) Stress - Top/Bottom
Unit: Pa
Time: 3.e-006
2016/10/16 14:44

Fig. 2.3.3

List the above data in a table to get Table 1.

Table 1 Three Data comparing

Height (mm)	Stress (MPa)
0.45	456
0.43	789
0.42	213

3. Conclusion

It can be seen that in the case of CeO_2 removal of the silicon surface, the corresponding removal shear stress is smaller for the height of the spherical distance plane at the same time and the same cutting speed.

References

[1] K. Karakoc, P.J. Edward, A. Suleman. Design considerations for an automotive automotive magnetorheological brake, Mechatronics, vol. 18(2008), 434-447.

[2] S.M. Fayyad. Experimental Investigation of Using MR Fluids in Automobiles Suspension Systems, Research Journal of Applied Sciences&Engineering and Technology, vol. 22(2010), 25-38.

[3] F.Imaduddin,S.A.Mazlan,H.Zamzuri. A design and modelling review of rotary magnetorheological damper, Materials and Design, vol. 51(2013), 54-60.

[4] C.J. Yi. Magnetic rheological liquid: preparation, performance testing and constitutive model (Chongqing University Press, China 2011) p. 20-30.

[5] B. Ioan, Y.D. Liu, H. J. Choi. Physical characteristics of magnetorheological suspensions and their applications, Journal of Industrial and Engineering Chemistry, vol. 19(2013), 394-406.

[6] J.S. Weng, H.Y. Hu, M.K. Zhang. Rheological mechanical properties test and modeling, Chinese Journal of Applied Mechanics of magnetorheological fluid, vol. 03(2000), 1-5+140.

[7] J.G. Lv, Z. Xing, M. Li. Analysis and experimental study of magnetic properties, magnetic materials and devices, vol. 03(2005), 21-23.

Feng Zhang: *Research on Magnetorheological finishing Technology* (Ph.D., Changchun Institute of Optics,Fine Mehcanics and Physics,Chinese Academy of Sciences, China 2000).