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A single PDC chip breaking mechanism and Simulation Analysis Based on Ansys Workbench

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Abstract:

In this paper, the finite element simulation method to establish a single PDC piece of dynamic nonlinear dynamic 3d simulation model of rock fragmentation.For the research of PDC bit cutting rock fragmentation mechanism, further analysis of PDC bit response law of rock fragmentation process, and for PDC provides theory basis for the researches on the mechanism of the rock.

Keywords — **Finite element simulation; PDC.; rock-breaking mechanism; response**

1. Introduction

PDC bit is along with the development of PDC composite material and a new type drilling tools, it USES the synthetic polycrystalline diamond compact as a cutting element to cutting and broken rock, and in soft to medium-hard formation has the very good can break the lithology, relative cone bit, its mechanical drilling rate is high, long life, the comprehensive economic benefit is remarkable, has a very broad application prospects. At present, the PDC bit is about 80% of the domestic drilling footage. The main features of PDC bit are structural changes, large design flexibility and strong sensitivity to applicable strata and applicable conditions. Therefore, the design of PDC bit is a key technology for each bit.

To improve the effect of PDC bit broken rock research mainly focuses on the experiments, and combining with the experience to optimize drilling bit design, but the test is expensive, and test process is not easy to control, so can make use of simulation technology to forecast the effect of rock fragmentation, which can greatly reduce test cost and risk. Based on 3d modeling software UG and ANSYS finite element analysis software of related knowledge, set up the finite element analysis model of PDC bit broken rock, analyzing the change of the cutting depth and cutting angle on the influence law of rock fragmentation effect, the researches on the mechanism of the rock damage to the PDC bit.

The Design of simulation analysis: using ANSYS Workbench Modeler module to establish all kinds of different shapes and sizes of PDC and different structure of PDC bit cutting rock pressure into the geometric model, again by the Static Structural and Transient Structural module of finite element analysis, the analysis results for reprocessing, finally combining with the Design Explorer module parameters for optimization analysis.

2. The establishment of a single PDC chip simulation model.

2.1 geometric model and material model.

When PDC is pressed into the cutting rock model, it is assumed that a single PDC piece is a rigid cylinder with a height of 10mm and a radius of 6.75mm. The rock adopts the axisymmetric cylinder, the radius and the cylinder height are relatively infinite, the model takes 50mm and 80mm respectively. The PDC film is pressed into the rock from the upper surface of the cylinder rock, and the geometric model is drawn using UG 8.0, and the ANSYS Workbench is imported as shown in figure 1.

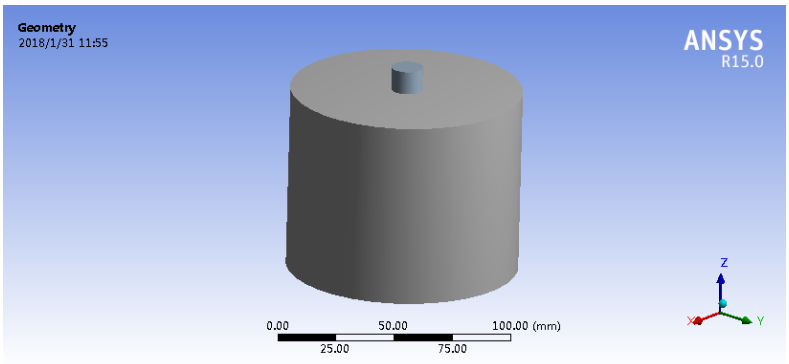

Fig. 1 schematic diagram of the geometrical model of a single PDC sheet pressed into the rock

For the material model, the stress and deformation of the rock are mainly considered, and the PDC adopts the material parameters with large rigidity. The rock adopts the material properties of brittle hard rock, as shown in table 1.

Table 1 material parameters of the simulation model

parameter name	modulus of elasticity(GPa)	poisson's ratio	tensile strength (MPa)	compressive strength (MPa)	shear strength (MPa)	Density (kg/m^3)
PDC	750	0.07	1290	7610	1100	3600
rock	/	/	5	200	16	2800

The deformation of rock material under external load is complicated, not only elastic deformation, but also shape deformation and even brittle fracture. In this case, the experimental data are entered into the Mechanical of ANSYS Workbench (table 2), as shown in figure 2, which can represent the stress-strain model in the rock.

Table 2 experimental data of single axial compression of rock material

strainε(‰)	0.7	1.22	2.03	2.44	2.64	2.85	3.26	3.69	4.32	4.51
stressσ(MPa)	32.18	58.20	107.59	134.20	146.01	159.60	185.92	217.45	248.57	240.20

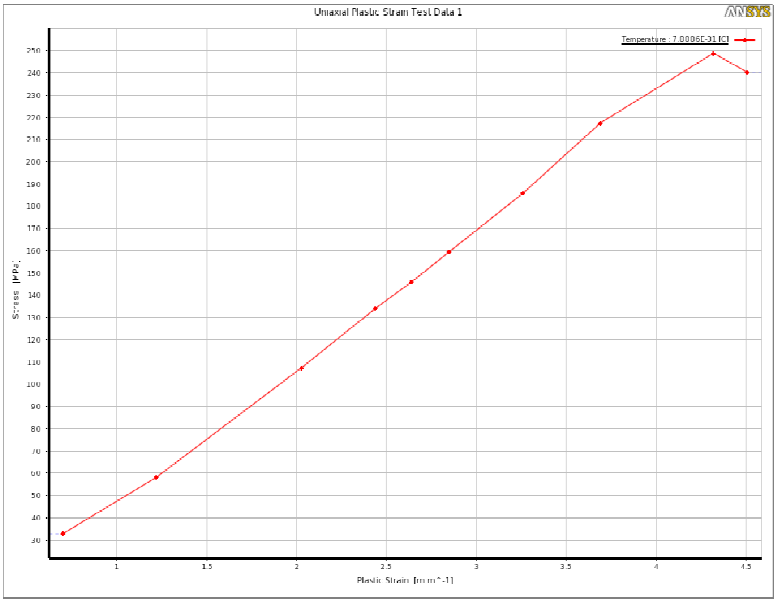

Fig. 2 stress strain diagram of rock material

2.2 contact analysis and grid division.

Based on ANSYS Workbench in three-dimensional geometry in five different mesh method and the specific geometric model, in order to save the calculation time, the reaction radius of 20 mm area was part of the rock for mesh refinement, in far away from the area with automatic partitioning, stress deformation position precision is highlighted. As shown in fig.3, the number of nodes in the model is 4154, and the number of units is 2189.

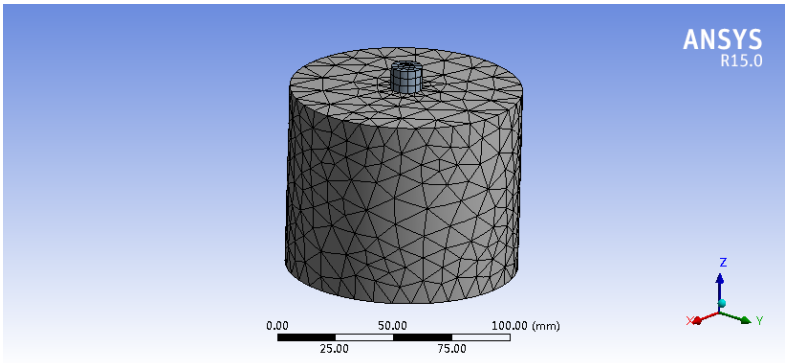

Fig 3. Simulation model grid partitioning results

2.3 load setting

In the finite element simulation analysis, the load is independent of the grid, and the load setting includes the boundary condition and the force setting. The load applied to the entity will be converted to its node or unit before the analysis is solved. The load on the PDC, or the load of the force, or the loading of the velocity. When the load of the force is applied, the force load is very difficult to repress the resistance balance between the rock and the PDC in the cutting process, resulting in the rotational behavior of the rigid PDC, which is not consistent with the actual drilling behavior. In order to ensure the comparison with the actual drilling program in PDC pressure into the cutting behavior, in statics analysis, using places displacement of the load on the PDC piece of geometry, the tangential displacement of 1 mm (tangential displacement); In the transient dynamic analysis, the load of velocity is applied on the geometry of PDC, and the z-axis velocity is 1mm/s. In the solution setting, set a time step completion, the time step is 1s, and the minimum and maximum cycle time steps are 0.05s and 0.1s respectively, as shown in figure 4.

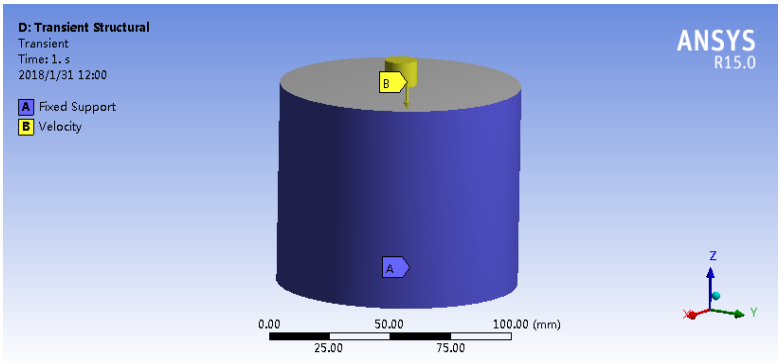

Fig. 4 boundary conditions and load diagram

3. Analysis of simulation results

The above model is solved and the result is analyzed. The influence of PDC on the depth of PDC and the influence of pressure on the depth of the PDC is analyzed. The effective stress cloud and total deformation of the rock are shown in FIG. 5 and FIG. 6. The upper part is the full model and the local enlargement. The lower part is the symmetrical section and the local enlargement.

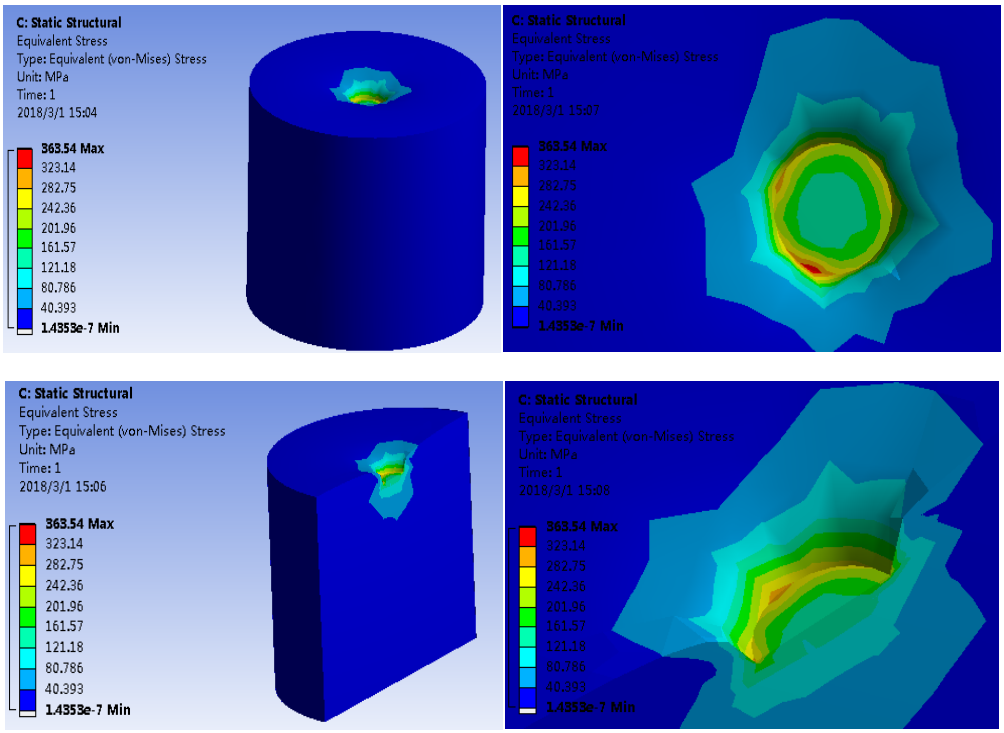

Fig. 5 the effective stress cloud of the rock

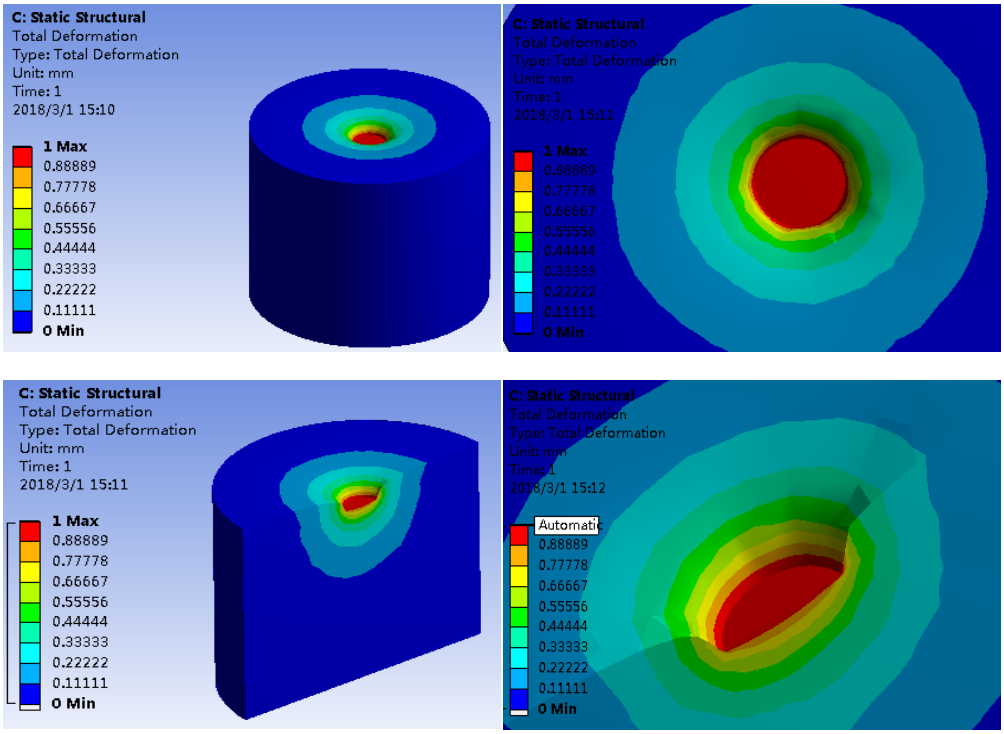

Fig. 6 total stress cloud of rock

Can be seen from the diagram, the PDC cutting rock, pressure into the PDC and rock stress and deformation are direct contact area is large, part of the deformation of the rock in the PDC cutting blade for 1 mm and stress of 363.54 MPa is maximum. Using mohr-coulomb Stress theory, the rock began to break down in a short time. The stress distribution is not uniform, and the extreme value exists along the cutting direction.

4 .Conclusion

In this paper, the numerical analysis of PDC pressed into rock by ANSYS Workbench finite element software is carried out, and a three-dimensional simulation model is established for the analysis of single PDC pieces. The following conclusions can be drawn:

When PDC films are pressed into rock, they are of great stress and deformation at the tip of the PDC. On the contact surface, the stress is not evenly distributed, but it is in accordance with the Hertz stress distribution. It can improve the design quality, shorten the design period and greatly improve the working efficiency by introducing the 3d solid model into ANSYS software.

In the future, it is suggested that the PDC bit with different structure should be made to carry out full-size bench test and field production test under the condition of mature conditions.

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